



A dataset of linear sweep voltammetry curves for the acidic oxygen reduction reaction on carbon-supported catalysts in a sulfuric acid medium

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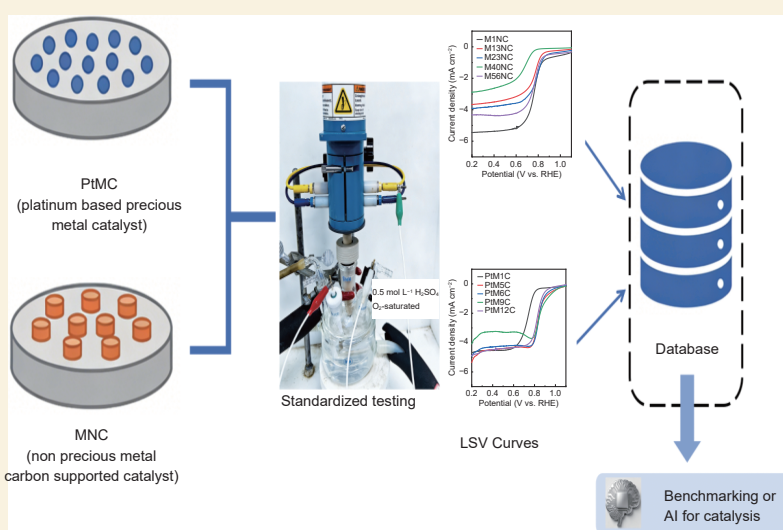
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Abstract: A standardized dataset of linear sweep voltammetry (LSV) curves for evaluating the oxygen reduction reaction performance of carbon-supported catalysts in acidic media is given. All electrochemical tests were conducted in O₂-saturated 0.5 mol L⁻¹ H₂SO₄ at controlled rotation speeds using a rotating disk electrode. The dataset contains 120 validated entries from both non-precious metal and platinum metal (Pt-MC) catalysts, including original LSV curves and extracted performance parameters such as onset potential, half-wave potential, and limiting current densities at different rotation speeds. Data processing involved potential conversion to the reversible hydrogen electrode scale, background subtraction, outlier removal, and reproducibility checks with defined quality control thresholds (relative standard deviation $\leq 2\%$ for $E_{1/2}$ $\leq 5\%$ for limiting current). The standardized collection serves as a reliable benchmark for catalyst performance comparison, supports kinetic and mass transport analysis, and provides a structured data source for machine learning applications in electrocatalysis.

Key words: ORR; Acidic electrolyte; Linear sweep voltammetry; Carbon-based catalyst; Dataset



1 Introduction

Hydrogen fuel cell technology provides an efficient and clean energy conversion solution, playing a key role in the global shift toward a low-carbon and sustainable energy structure. The technology directly transforms chemical energy into electrical power through the hydrogen-oxygen reaction, with potential uses in transportation, distributed power generation, and portable devices. However, large-scale commercialization faces challenges from the performance of key electrochemical components, especially the slow

kinetics and high overpotential of the cathodic oxygen reduction reaction (ORR) (Fig. 1)^[1–2]. ORR is the rate-determining step in fuel cell energy conversion, involving complex multi-step proton-coupled electron transfer and mass transport limitations at multiphase interfaces. Developing ORR catalysts that are

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highly active, stable, and cost-effective remains central to advancing fuel cell technology^[3–4].

Carbon-based supports are good carriers for catalytic active components. They offer good conductivity, high surface area, controllable pores, and chemical stability^[5–6]. With careful structural design of the carbon carrier, active sites can be dispersed effectively, mass transfer of reactants and products can be enhanced, and catalyst stability can be improved. Current research falls into 2 main categories based on the nature of the active centers. One category includes precious metal catalysts, typified by platinum and its alloys. After decades of work, these materials benefit from mature preparation techniques and high intrinsic catalytic activity, representing the current performance benchmark for commercial fuel cells. Nevertheless, platinum suffers from limited global reserves, high cost, and stability issues (dissolution, aggregation, and poisoning) under harsh acidic conditions, which limit widespread adoption^[7–8]. The second category covers non-precious metal catalysts, mainly transition metal-nitrogen-carbon (M-N-C) composites. In recent years, such materials have shown ORR activity in acidic media that approaches or even exceeds that of traditional Pt-based catalysts, offering a way to avoid dependence on precious metals and associated cost barriers. Their activity typically comes from M-N_x coordination structures formed by atomically dispersed metal centers in a nitrogen-doped carbon matrix^[9–10]. These two research paths coexist and complement each other, driving the field forward.

Although many novel catalyst materials have been reported, standardization of performance evaluation and comparison remains inadequate. LSV is the most common half-cell technique for assessing ORR catalytic activity. The scientific validity and comparability of LSV results depend strongly on strict uniformity across experimental conditions and data processing. In practice, research practices vary widely. Different groups use different test parameters due to different habits and equipment. As Table 1 shows, there are differences in electrolyte type and concentration, scan rate, rotation speed sequences, catalyst ink

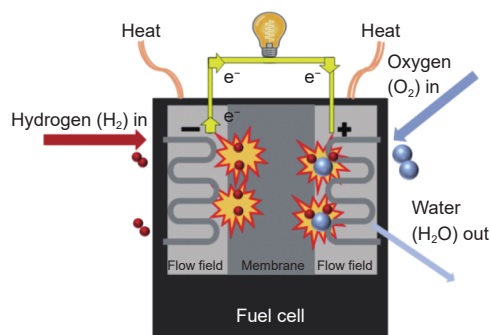


Fig. 1 Schematic diagram of the working principle of fuel cells

formulation, electrode loading, and data processing methods. These variations often prevent direct and fair comparison of polarization curves and key performance metrics reported in the literature. This lack of standardization causes notable problems. First, performance claims for new materials often lack a stable reference frame, making it hard to judge their true technical level and potentially leading to over or underestimation of their innovative value. Second, it hinders rational, data-driven catalyst design and the application of machine learning. Effective data mining and model training require high-quality, highly consistent datasets. The prevalence of “noisy” and non-standardized data in the literature makes it very difficult to extract universal “structure-performance” relationship rules. As a result, researchers are often limited to correlation analyses within small, self-generated datasets, slowing the transition from empirical “trial-and-error” to “rational design” approaches.

To address these issues, we constructed a standardized dataset of LSV curves for carbon-supported ORR catalysts in 0.5 mol L⁻¹ H₂SO₄. The dataset covers both precious and non-precious metals (120 samples total), all tested under identical conditions. Data processing was uniform: potential conversion to RHE and repeatability checks. The dataset provides a reference benchmark, supports kinetic studies, and offers a structured data source for machine learning.

2 Data collection and processing methods

2.1 Experimental materials and preparation

We selected two of the most important carbon-

Table 1 Oxygen reduction (ORR) test conditions reported in the different literature

Samples	Electrolyte concentrations	Scan rate/(mV·s ⁻¹)	Speed range/(r min ⁻¹)	Ref.
Pt-(Nb-Ti) ₂ AlC	0.5 mol L ⁻¹ H ₂ SO ₄	20	600, 900, 1600, 2500, 3000 and 3400	[11]
Pt/C	0.1 mol L ⁻¹ HClO ₄	10	400, 800, 1200, 1600, 2000 and 2500	[12]
Co ₃ (HADQ) ₂	0.5 mol L ⁻¹ H ₂ SO ₄	5	400, 625, 900, 1225, 1600, 2025 and 2500	[13]
Zn-N-P/NPC	0.1 mol L ⁻¹ KOH or 0.1 mol L ⁻¹ HClO ₄	5	400, 625, 900, 1225 and 1600	[14]
Pt(111)	0.1 and 0.02 mol L ⁻¹ HClO ₄	20	1600	[15]
Fe-Zn@SNC	0.5 mol L ⁻¹ H ₂ SO ₄	5	225, 400, 625, 900, 1225 and 1600	[16]
Mn-Fe-N-C SAC	0.1 mol L ⁻¹ HClO ₄	5	1000, 1300, 1600, 1900 and 2200	[17]

supported catalysts in acidic ORR research to build a dataset with broad representativeness and practical reference value. Precious metal catalysts include laboratory-synthesized platinum-based alloy catalysts, such as PtMC (M = Fe, Co, etc.). Non-precious metal catalysts are transition metal-nitrogen-carbon (MNC) catalysts synthesized in the laboratory, covering various metal centers (iron, cobalt). All catalyst powders were thoroughly dried before use to remove adsorbed water.

To keep the experimental environment consistent with the actual working conditions of proton exchange membrane fuel cells, the electrolyte was 0.5 mol L⁻¹ H₂SO₄. We prepared it by slowly adding analytical grade concentrated sulfuric acid to ultrapure water under cooling and stirring, then diluting to the required volume. Before use, the electrolyte was bubbled with high-purity oxygen for at least 30 min to reach saturation, and a stable oxygen flow was maintained throughout testing to simulate continuous gas supply to the fuel cell cathode and ensure a constant oxygen concentration at the reaction interface. Because of intellectual property constraints (unpublished results and samples provided by collaborating groups), detailed synthesis procedures are not disclosed in this dataset. However, basic physicochemical properties (catalyst category, metal center(s), and metal loading) are provided in Table S1. These parameters allow meaningful categorization and comparison while protecting confidential information. Full synthetic details will be published in subsequent articles.

The working electrode was prepared by drop-coating. First, accurately weighed catalyst powder, Nafion solution, and ethanol solvent were mixed and ultrasonicated for a long time to form a uniformly dis-

persed slurry^[18]. Then, a fixed volume of slurry was dropped onto the surface of a glassy carbon electrode (which had been rigorously polished and cleaned) using a micropipette, and allowed to dry naturally at room temperature to form a catalytic layer. By controlling the slurry concentration and drop volume, the catalyst loading was kept within a typical range, ensuring relevance to real applications.

2.2 Data acquisition system and experimental procedure

Electrochemical testing used a precision electrochemical workstation with a rotating disk electrode module. The testing system had a standard three-electrode configuration: the catalyst-loaded glassy carbon electrode as the working electrode, an Ag/AgCl electrode filled with saturated KCl solution as the reference electrode, and a platinum plate as the counter electrode. All experiments were conducted in a temperature-controlled laboratory to minimize environmental fluctuations.

We calibrated the Ag/AgCl (sat. KCl) reference electrode weekly against a reversible hydrogen electrode (RHE) in the same electrolyte. The calibration potential was determined by measuring the open-circuit potential of a Pt foil in H₂-saturated 0.5 mol L⁻¹ H₂SO₄, giving $E_{\text{RHE}}(\text{V}) = E_{\text{Ag/AgCl}}(\text{V}) + 0.215$ at 25 °C (pH=0.3). Drift exceeding ±2 mV triggered recalibration. Then the complete testing process began with system assembly and electrode activation. We immersed the working, reference, and counter electrodes in an electrolytic cell filled with oxygen-saturated electrolyte. The atmosphere was oxygen, and after stabilization, linear sweep voltammetry started. The LSV potential range was from 0.2 to 1.1 V (vs. RHE). To study the effect of oxygen mass transfer on

the reaction, tests were conducted sequentially at a series of standardized rotation speeds. Each catalyst sample was tested at each speed at least three times independently, providing the basis for evaluating random errors and ensuring reliability. All raw current-potential-time data were automatically recorded and stored by the instrument software.

2.3 Data preprocessing and standardization

Raw data were processed in several steps to create a high-quality, comparable dataset. The key steps included data cleaning, benchmark conversion, and parameter extraction. First, we converted the potential reference. Because the experiment directly measured potential relative to the Ag/AgCl reference electrode, and the RHE is the common reporting reference, precise conversion was necessary. The conversion formula accounted for the actual pH of the electrolyte and the calibration potential of the reference electrode relative to the standard hydrogen electrode^[19]. We determined this key parameter through regular calibration and applied the calibration values to all data, ensuring accuracy and internal consistency of the potential axis. Next, data cleaning and background correction were performed. The original LSV curves may contain outliers from instrument noise, external interference, or transient changes on the electrode surface. We used statistical methods combined with smoothing algorithms to identify and eliminate these outliers, obtaining smooth and reliable polarization curves.

After obtaining a clean, standardized polarization curve, key performance parameters were extracted programmatically. These parameters include onset potential (E_{onset}), defined as the potential at which a specific current density is reached, reflecting the thermodynamic tendency for reaction initiation; half-wave potential ($E_{1/2}$), the potential at which the current density reaches half of the limiting current density, serving as a key indicator of intrinsic catalytic activity; and the limiting current density measured at different rotation speeds, used to analyze mass transport processes. The limiting current density was taken as the average value over the potential plateau region. Fi-

nally, repeatability verification and data screening were key to data reliability. For each catalyst, three parallel tests were conducted at each speed to calculate the average and relative standard deviation (RSD) of the half-wave potential. We set a quality control threshold of $\leq 2\%$ RSD for $E_{1/2}$. Parallel experiments with RSD exceeding this range were repeated, and the average value was reported. This process effectively filters out unreliable data caused by operational contingencies, ensuring that every data unit in the final dataset has high repeatability and robustness.

2.4 Data sample description

This dataset is the result of long-term systematic research in our group, gathering standardized test results from over 25 different compositions and structures of carbon-supported catalysts. Based on the fundamental properties of catalyst active centers, all data are divided into two main categories, each containing rich subclasses. Thus, the sample set is hierarchical and informative. The non-precious metal carbon-supported catalyst (MNC) category contains 60 effective data units, representing the diversity and frontiers of current research in this field. It mainly includes transition metal-nitrogen-carbon (M-N-C) and bimetallic M1M2-N-C catalysts (test speed sequence: 400, 625, 900, 1225, 1600, 2025 and 2500 r min^{-1}). Some non-precious metal catalysts have polarization curve shapes similar to precious metals, showing high activity and four-electron selectivity; others show different kinetic characteristics or selectivity, providing valuable examples for understanding structure-performance relationships. The platinum-based precious metal catalyst (PtMC) category also contains 60 effective data units (test speed sequence: 400, 800, 1200, 1600, 2000, and 2400 r min^{-1}), mainly laboratory-prepared platinum-based alloy catalysts and commercial carbon-supported platinum catalysts. Their LSV limiting current densities increase regularly with speed, clearly showing typical mass-transfer-controlled behavior. To illustrate the differences in electrochemical performance between ORR catalysts, we selected representative LSV curves (Fig. 2). Although the rotation speed sequences differ between MNC (400–2500 r min^{-1} ,

seven speeds) and PtMC (400 ~ 2400 r min⁻¹, six speeds), direct cross-category comparison of intrinsic activity is based on the $E_{1/2}$, which is independent of mass transport. For limiting current densities, only within-category comparisons are recommended.

To give a concise overview of core performance, the dataset includes 2 summary tables that compile key metrics across all catalysts. Table 2 lists the electrochemical performance of 60 non-precious metal catalysts (M1NC-M60NC), including onset potential, half-wave potential, and limiting current densities at seven rotation speeds. Table 3 summarizes the performance of Pt-based noble metal catalysts (PtM1C-PtM60C) at 6 rotation speeds.

In addition to the tabulated data, the statistical distribution of half-wave potentials across all catalysts is summarized in Fig. 3. The box plot reveals a clear performance gap between MNC and PtMC catalysts.

The distribution of E_{onset} for the 2 catalyst categories is presented in Fig. 4. Compared with $E_{1/2}$, E_{onset} shows a narrower range and higher median values for both MNC and PtMC.

2.5 Data quality control and assessment

Dataset quality and reliability determine its scientific value and usefulness. Therefore, we established a quality control and assurance system that runs through the entire data generation chain, ensuring that every data point can withstand scrutiny. Quality control begins with standardization at the source of experimental design. We set uncompromising uniform conditions for all tests, fixed electrolyte formula and con-

centration, strictly controlled oxygen saturation, constant ambient temperature, uniform potential scan rate and range, and a pre-defined speed sequence. This high consistency from the source is the fundamental prerequisite for ensuring comparability of all subsequent data, minimizing systematic errors from fluctuations in testing conditions.

Monitoring instrument status and operating standards is crucial during data collection. All key equipment (electrochemical workstation, rotating electrode controller, high-precision balances) underwent regular calibration and maintenance. Especially for the reference electrode used as the potential benchmark, we kept a detailed file and regular calibration system. Its potential was verified before and after use; any drift beyond the allowable range triggered recalibration or replacement, ensuring long-term accuracy. Experimental operations strictly followed written standard operating procedures to reduce human variation. Data repeatability validation and statistical screening were the cornerstones of quality control. Each testing condition underwent at least three independent, complete parallel experiments. We set acceptable RSD thresholds, $\leq 2\%$ for $E_{1/2}$ and $\leq 5\%$ for limiting current density. The reference electrode drift was allowed within ± 2 mV; otherwise recalibration was performed. The electrochemical workstation was calibrated every three months, and rotator speed accuracy was verified monthly. Any measurement exceeding these thresholds was repeated.

2.6 Typical case analysis

From the 60 MNC and 60 PtMC catalysts in

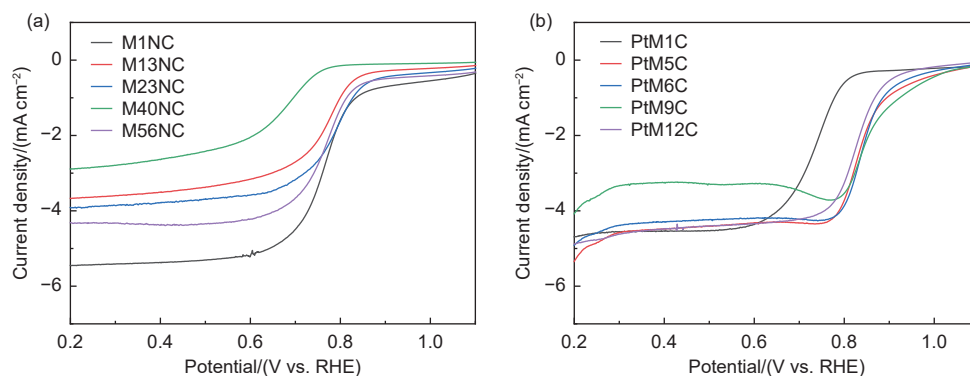


Fig. 2 Linear sweep voltammetry (LSV) curves of representative carbon-supported ORR catalysts in O₂-saturated 0.5 mol L⁻¹ H₂SO₄ electrolyte at 1600 r min⁻¹

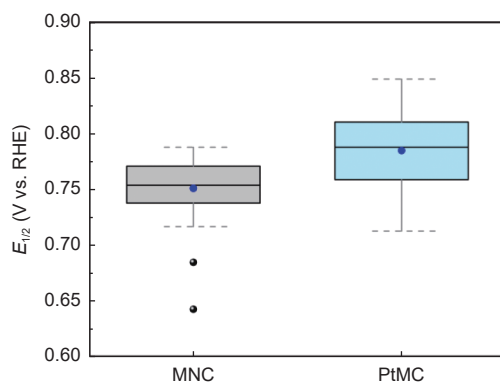


Fig. 3 Statistical distribution of half-wave potential ($E_{1/2}$) for non-precious metal (MNC, $n=60$) and precious metal (PtMC, $n=60$) catalysts. Box plots show the median (center line), interquartile range (box), whiskers ($1.5 \times \text{IQR}$), and outliers (points). Data are derived from Table 2 and Table 3

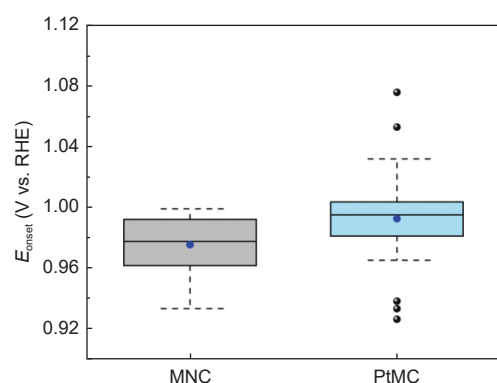


Fig. 4 Statistical distribution of onset potential (E_{onset}) for non-precious metal (MNC, $n=60$) and precious metal (PtMC, $n=60$) catalysts. Box plots show the median (center line), interquartile range (box), whiskers ($1.5 \times \text{IQR}$), and outliers (points). Data are derived from Table 2 and Table 3

Tables 2 and 3, we selected three representative samples from each category for detailed comparison: the highest-activity (M56NC, PtM9C), a medium-activity or benchmark (M13NC, PtM6C), and the lowest-activity (M40NC, PtM1C). To visually present the performance distribution and comparative value of the dataset, this section analyzes representative cases. Among non-precious metal (MNC) catalysts, M56NC has a relatively high half-wave potential (0.787 V), approaching the benchmark of commercial catalysts. Samples such as M13NC and M23NC achieve a balance between half-wave potential (~ 0.78 V) and maximum current density. M40NC ($E_{1/2} = 0.684$ V) represents a typical case where activity still needs improvement. Overall, non-precious metal catalysts exhibit a wide activity distribution in acidic media. For PtMC catalysts, PtM9C shows the upper limit of in-

trinsic activity of current platinum-based materials, with a half-wave potential of 0.848 V. PtM5C and PtM12C maintain a high half-wave potential (0.840 V) while also having higher limiting current density or onset potential. PtM6C has similar performance to commercial Pt/C catalysts ($E_{1/2} = 0.832$ V). These cases provide a clear reference system for developing catalysts with different application orientations, as shown in Fig. 5.

2.7 Data value and limitation

This dataset is intended as a community resource rather than a record of one research project. It addresses three common problems in ORR research: inconsistent performance benchmarks, lack of reproducible data for model validation, and limited cross-study comparability. First, the dataset provides a benchmark reference for ORR catalyst performance evaluation under standardized conditions. Researchers can directly compare their new material data with this dataset when following the same testing protocols. Second, the variable rotation speeds provide dynamic and mass-transfer coupling information, useful for validating theoretical models. Third, the testing conditions (acidic medium, $0.5 \text{ mol L}^{-1} \text{ H}_2\text{SO}_4$, O_2 -saturated) closely match the cathode environment of proton exchange membrane fuel cells, offering practical guidance for fuel cell engineers.

This dataset is applicable to ORR measurements in $0.5 \text{ mol L}^{-1} \text{ H}_2\text{SO}_4$, O_2 -saturated, at room temperature ($25 \pm 2^\circ \text{C}$), using a rotating disk electrode with the specified rotation protocols. It does not cover other electrolytes (e.g., KOH, HClO_4), elevated temperatures, gas diffusion electrodes, or long-term stability/durability tests. Users should replicate the same experimental conditions for valid comparisons. This LSV dataset for acidic ORR on carbon-supported catalysts is a carefully designed and controlled research resource. It is not only a record of experimental results but also a ruler for performance measurement, a mineral deposit for mechanism research, and an incubator for innovative research and development (R&D). We look forward to promoting broader academic cooperation through open sharing, inspiring

Table 2 Electrochemical performance of carbon-supported non-precious metal catalysts

Sample	$E_{\text{onset}}/\text{V}$	$E_{1/2}/\text{V}$	Limiting current/(mA cm ⁻²)						
			400 r min ⁻¹	625 r min ⁻¹	900 r min ⁻¹	1225 r min ⁻¹	1600 r min ⁻¹	2025 r min ⁻¹	2500 r min ⁻¹
M1NC	0.985	0.763	3.416	3.991	4.533	5.079	5.523	5.834	6.081
M2NC	0.959	0.751	2.526	2.916	3.294	3.672	4.015	4.339	4.646
M3NC	0.958	0.761	2.312	2.688	3.058	3.341	3.519	3.855	4.283
M4NC	0.941	0.774	2.384	2.773	3.143	3.488	3.826	4.158	4.420
M5NC	0.996	0.757	2.279	2.678	3.058	3.431	3.782	4.113	4.359
M6NC	0.968	0.766	2.941	3.495	4.024	4.497	4.630	5.164	5.258
M7NC	0.964	0.761	2.790	3.303	3.792	4.230	4.602	4.840	4.917
M8NC	0.995	0.716	2.567	3.052	3.532	4.029	4.537	5.050	5.588
M9NC	0.993	0.772	2.149	2.579	3.042	3.413	3.794	4.158	4.497
M10NC	0.976	0.761	2.441	2.888	3.301	3.737	4.158	4.578	4.929
M11NC	0.957	0.775	2.181	2.523	2.867	3.163	3.451	3.684	3.823
M12NC	0.953	0.735	2.168	2.525	2.875	3.214	3.516	3.823	4.125
M13NC	0.981	0.782	2.307	2.703	3.076	3.411	3.733	4.053	4.343
M14NC	0.942	0.748	2.758	3.281	3.756	4.234	4.679	4.974	5.006
M15NC	0.991	0.774	2.853	3.333	3.814	4.287	4.699	5.091	5.422
M16NC	0.993	0.776	2.359	2.729	3.138	3.521	3.909	4.275	4.578
M17NC	0.996	0.774	3.267	3.712	4.178	4.594	4.998	5.362	5.677
M18NC	0.973	0.777	2.204	2.619	3.046	3.406	3.779	4.230	4.659
M19NC	0.968	0.748	2.377	2.726	3.060	3.364	3.641	3.874	4.073
M20NC	0.949	0.743	2.314	2.773	2.203	3.637	4.044	4.444	4.840
M21NC	0.966	0.756	2.394	2.777	3.178	3.566	3.920	4.331	4.638
M22NC	0.967	0.769	2.457	2.842	3.263	3.654	4.035	4.396	4.739
M23NC	0.958	0.782	2.446	2.862	3.259	3.621	3.987	4.315	4.630
M24NC	0.967	0.737	2.223	2.583	2.985	3.103	3.632	3.929	4.226
M25NC	0.998	0.727	2.104	2.567	2.857	3.198	3.562	3.853	4.133
M26NC	0.956	0.748	2.151	2.537	2.931	3.311	3.711	4.105	4.529
M27NC	0.997	0.775	3.069	3.635	4.158	4.675	5.333	5.762	6.198
M28NC	0.993	0.774	3.214	3.792	4.251	4.885	5.438	6.121	6.489
M29NC	0.985	0.774	3.228	3.738	4.158	4.533	4.949	5.414	5.834
M30NC	0.994	0.771	2.314	2.773	3.203	3.637	4.044	4.444	4.840
M31NC	0.987	0.729	2.223	2.583	2.985	3.103	3.632	3.929	4.226
M32NC	0.961	0.745	2.151	2.537	2.931	3.311	3.711	4.105	4.529
M33NC	0.957	0.753	2.459	2.912	3.394	3.839	4.343	4.849	5.293
M34NC	0.988	0.766	2.934	3.540	4.113	4.642	5.192	5.491	5.551
M35NC	0.961	0.737	3.024	3.605	4.174	4.671	5.071	5.398	5.665
M36NC	0.968	0.748	2.968	3.529	4.053	4.513	4.873	5.071	5.159
M37NC	0.991	0.732	2.479	2.991	3.458	3.915	4.234	4.618	4.893
M38NC	0.962	0.740	2.829	3.422	4.035	4.699	5.305	5.915	6.347
M39NC	0.987	0.722	2.492	3.007	3.419	3.594	4.315	4.779	5.236
M40NC	0.982	0.684	1.995	2.396	2.627	2.794	2.944	3.034	3.164
M41NC	0.983	0.756	2.646	3.203	3.625	3.936	4.251	4.554	4.840
M42NC	0.964	0.735	2.886	3.375	3.803	4.162	4.465	4.885	5.345
M43NC	0.998	0.735	2.834	3.332	3.869	4.420	5.006	5.349	5.568
M44NC	0.964	0.642	2.100	2.539	2.880	3.137	3.391	3.628	3.865
M45NC	0.956	0.741	2.656	3.221	3.574	3.865	4.109	4.246	4.428
M46NC	0.979	0.743	2.599	3.023	3.406	3.783	4.113	4.428	4.731
M47NC	0.994	0.739	2.724	3.254	3.781	4.271	4.768	5.164	5.729
M48NC	0.972	0.719	2.740	3.280	3.813	4.343	4.836	5.369	5.657
M49NC	0.999	0.729	2.757	3.201	3.643	4.037	4.420	4.743	4.869
M50NC	0.943	0.718	2.604	3.078	3.595	4.105	4.610	5.159	5.624
M51NC	0.993	0.732	2.461	3.160	3.640	4.101	4.493	4.913	5.224
M52NC	0.967	0.753	2.998	3.531	3.914	4.226	4.525	4.820	5.010

Table 2 (Continued).

Sample	$E_{\text{onset}}/\text{V}$	$E_{1/2}/\text{V}$	Limiting current/(mA cm ⁻²)						
			400 r min ⁻¹	625 r min ⁻¹	900 r min ⁻¹	1225 r min ⁻¹	1600 r min ⁻¹	2025 r min ⁻¹	2500 r min ⁻¹
M53NC	0.933	0.754	2.941	3.495	4.024	4.497	4.630	5.164	5.358
M54NC	0.969	0.753	2.193	2.605	2.983	3.399	3.775	4.117	4.448
M55NC	0.991	0.774	2.884	3.337	3.747	4.166	4.578	4.994	5.410
M56NC	0.995	0.787	2.557	3.015	3.451	3.895	4.311	4.735	5.168
M57NC	0.984	0.753	2.724	3.171	3.625	4.053	4.485	4.943	5.358
M58NC	0.991	0.753	2.892	3.403	3.966	4.457	4.945	5.398	5.782
M59NC	0.997	0.758	3.204	3.620	4.065	4.497	4.974	5.434	5.875
M60NC	0.985	0.757	2.929	3.436	3.943	4.448	4.913	5.345	5.762

Table 3 Electrochemical performance of Pt-based noble metal catalysts supported on carbon-based substrates

Sample	$E_{\text{onset}}/\text{V}$	$E_{1/2}/\text{V}$	Limiting current/(mA cm ⁻²)					
			400 r min ⁻¹	800 r min ⁻¹	1200 r min ⁻¹	1600 r min ⁻¹	2000 r min ⁻¹	2400 r min ⁻¹
PtM1C	1.001	0.761	2.737	3.604	4.251	4.857	5.265	5.669
PtM2C	0.998	0.769	2.521	3.245	3.761	4.295	4.570	4.857
PtM3C	0.995	0.758	2.729	3.767	4.594	5.317	5.952	6.489
PtM4C	1.009	0.748	2.941	3.762	4.376	4.970	5.317	5.685
PtM5C	1.006	0.840	3.277	4.141	4.792	5.325	5.802	6.214
PtM6C	0.995	0.832	2.829	3.681	4.368	4.905	5.366	5.735
PtM7C	0.998	0.801	2.787	3.730	4.448	5.026	5.539	5.972
PtM8C	0.993	0.843	2.553	3.194	3.684	4.141	4.719	5.754
PtM9C	0.998	0.848	2.801	3.392	3.775	4.061	4.356	4.707
PtM10C	0.979	0.840	2.619	3.472	4.129	4.655	5.107	5.442
PtM11C	0.975	0.832	3.737	4.604	4.252	4.267	5.266	5.670
PtM12C	0.986	0.801	2.521	3.245	3.762	4.829	4.571	4.858
PtM13C	1.02	0.843	2.729	3.767	4.594	5.318	5.952	6.490
PtM14C	1.027	0.848	2.941	3.762	4.376	4.971	5.317	5.686
PtM15C	1.017	0.840	3.278	4.142	4.792	5.326	5.802	6.215
PtM16C	0.999	0.832	2.829	3.681	4.368	4.906	5.366	5.735
PtM17C	0.987	0.801	2.787	3.730	4.448	5.027	5.539	5.972
PtM18C	0.993	0.843	2.553	3.194	3.866	4.141	4.721	5.754
PtM19C	0.995	0.848	2.801	3.392	3.957	4.061	4.370	4.708
PtM20C	1.076	0.840	2.619	3.472	4.130	4.655	5.108	5.443
PtM21C	1.032	0.832	4.737	5.604	4.253	4.139	5.267	5.671
PtM22C	0.969	0.801	2.521	3.245	3.763	4.195	4.572	4.859
PtM23C	0.938	0.843	2.729	3.767	4.594	5.319	5.952	6.491
PtM24C	1.022	0.848	2.941	3.762	4.376	4.972	5.317	5.687
PtM25C	1.053	0.840	3.279	4.143	4.792	5.327	5.802	6.216
PtM26C	1.019	0.832	2.829	3.681	4.368	4.907	5.366	5.735
PtM27C	0.972	0.801	2.787	3.730	4.448	5.028	5.539	5.972
PtM28C	0.969	0.843	2.553	3.194	3.105	4.141	4.733	5.754
PtM29C	0.926	0.848	2.801	3.392	3.114	4.061	4.109	4.709
PtM30C	0.968	0.840	2.619	3.472	4.131	4.655	5.109	5.444
PtM31C	1.006	0.832	5.737	6.604	4.254	4.252	5.268	5.672
PtM32C	0.996	0.801	2.521	3.245	3.764	4.308	4.573	4.860
PtM33C	0.996	0.843	2.729	3.767	4.594	5.320	5.952	6.492
PtM34C	1.003	0.848	2.941	3.762	4.376	4.973	5.317	5.688
PtM35C	1.004	0.840	3.280	4.144	4.792	5.328	5.802	6.217
PtM36C	1.004	0.832	2.829	3.681	4.368	4.908	5.366	5.735
PtM37C	0.994	0.801	2.787	3.730	4.448	5.029	5.539	5.972
PtM38C	0.998	0.843	2.553	3.194	3.123	4.141	4.146	5.754
PtM39C	0.999	0.848	2.801	3.392	3.132	4.061	4.182	4.710

Table 3 (Continued).

Sample	$E_{\text{onset}}/\text{V}$	$E_{1/2}/\text{V}$	Limiting current/(mA cm ⁻²)					
			400 r min ⁻¹	800 r min ⁻¹	1200 r min ⁻¹	1600 r min ⁻¹	2000 r min ⁻¹	2400 r min ⁻¹
PtM40C	0.985	0.840	2.619	3.472	4.132	4.655	5.110	5.445
PtM41C	0.974	0.832	6.737	7.604	4.255	4.364	5.269	5.673
PtM42C	0.988	0.801	2.521	3.245	3.765	4.420	4.574	4.861
PtM43C	0.965	0.843	2.729	3.767	4.594	5.321	5.952	6.493
PtM44C	1.001	0.848	2.941	3.762	4.376	4.974	5.317	5.689
PtM45C	0.966	0.840	3.281	4.145	4.792	5.329	5.802	6.218
PtM46C	1.006	0.832	2.829	3.681	4.368	4.909	5.366	5.735
PtM47C	0.968	0.801	2.787	3.730	4.448	5.030	5.539	5.972
PtM48C	0.984	0.843	2.553	3.194	3.141	4.141	4.219	5.754
PtM49C	0.985	0.848	2.801	3.392	3.151	4.061	4.255	4.711
PtM50C	0.983	0.840	2.619	3.472	4.133	4.655	5.111	5.446
PtM51C	0.984	0.832	7.737	8.604	4.256	4.476	5.270	5.674
PtM52C	0.933	0.801	2.521	3.245	3.766	4.533	4.575	4.862
PtM53C	0.993	0.843	2.729	3.767	4.594	5.322	5.952	6.494
PtM54C	1.003	0.848	2.941	3.762	4.376	4.975	5.317	5.690
PtM55C	0.998	0.840	3.282	4.146	4.792	5.330	5.802	6.219
PtM56C	0.987	0.832	2.829	3.681	4.368	4.910	5.366	5.735
PtM57C	0.993	0.801	2.787	3.730	4.448	5.031	5.539	5.972
PtM58C	0.966	0.843	2.553	3.194	3.159	4.141	4.291	5.754
PtM59C	0.965	0.848	2.801	3.392	3.169	4.061	4.327	4.712
PtM60C	1.009	0.840	2.619	3.472	4.134	4.655	5.112	5.447

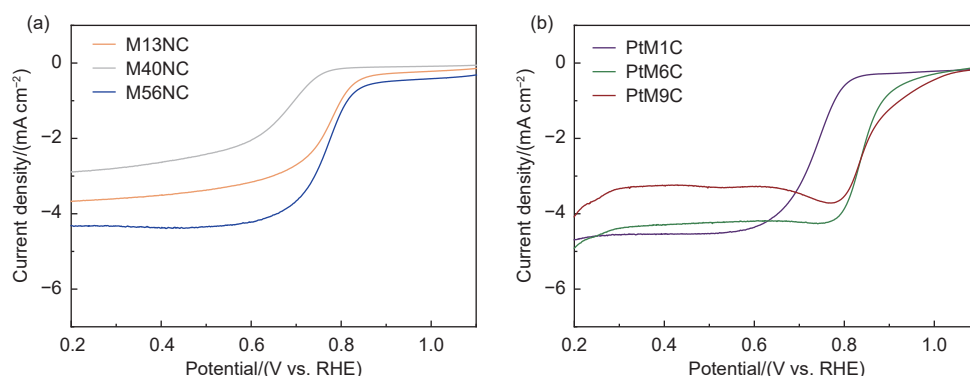


Fig. 5 Comparison of linear sweep voltammetry curves of typical catalysts at 1600 r min⁻¹. (a) LSV curves of selected MNC catalysts (M56NC, M13NC, M40NC), showing their activity distribution. (b) Selected PtMC LSV curves (PtM9C, PtM6C, PtM1C), demonstrating clear performance benchmarks

new scientific questions, and contributing solid data power to the advancement of clean energy technology.

3 Conclusion and outlook

We built and released an LSV dataset for acidic ORR on carbon-supported catalysts. It addresses inconsistent test conditions and poor data comparability in current research. The dataset covers precious and non-precious metals (120 valid data sets), obtained through a unified experimental environment (0.5 mol L⁻¹ H₂SO₄, O₂-saturated), standardized testing procedures, and strict data quality control (outlier

cleaning, potential conversion to RHE, repeatability verification). This dataset provides a fair and reliable benchmark for comparing catalyst performance, offers high-quality experimental data for understanding reaction kinetics, mass transfer behavior, and structure-performance relationships, and supplies a structured data foundation for machine learning and AI-driven material design. This work fills the gap in high-quality, standardized datasets in acidic ORR and helps push fuel cell catalyst research toward a more rigorous, reproducible, and data-driven direction.

Although this dataset is comprehensive in con-

tent, it is intended as a dynamic resource that can be expanded and improved over time. Future versions may include more catalyst families (e.g., perovskite oxides, transition metal oxides), expand temperature ranges, or include supplementary characterization data (X-ray absorption spectroscopy, transmission electron microscopy) to enrich structure-performance correlations. In addition, this dataset can be linked to computational descriptors such as adsorption energy, d-band center, or coordination number, creating a multimodal resource for machine learning applications. The ultimate goal is to establish a continuously updated, community-reviewed reference database for ORR electrocatalysis, reflecting the latest technological level and promoting its development. We invite researchers to use, evaluate, and contribute to this resource to ensure its relevance and value as the field advances.

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