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A ternary catalyst 5Nb:1Ce:1La applied in hydrogen peroxide electrogeneration

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This study aimed to develop a ternary catalyst based on niobium, cerium, and lanthanum for graphene modification, with applications in hydrogen peroxide electrogeneration [1-2]. The catalyst was synthesized by dissolving 1 g of Nb_2O_5, 200 mg of $CeCl_3$, and 200 mg of La_2O_3 in 20 mL of distilled water, placed in a Teflon capsule. Subsequently, 10 g of NaOH diluted in 5 mL of distilled water was added slowly to the mixture, stirring for 30 minutes. After mixing, the capsule was sealed and placed in a hydrothermal reactor at 100°C for 24 hours. Following the hydrothermal process, the catalyst was washed three times (first with water, then 50% isopropyl alcohol, and finally water again), centrifuged at 5,000 rpm, dried at 80°C for 10 hours, and calcined at 500°C for 3 hours. The ternary catalyst was characterized by Raman spectroscopy, showing characteristic bands at 230 cm^{-1} for Nb_2O_5, 500 cm^{-1} for CeO_2, and approximately 850 cm^{-1} for La_2O_3. XRD analysis revealed peaks at 20° (Ce), 32° (Nb), and 55° (La). Scanning electron microscopy (SEM) images indicated the formation of nanorods, with energy-dispersive X-ray spectroscopy (EDX) confirming the presence of cerium and lanthanum, and niobium incorporated into these filamentous structures. Electrochemical experiments using a rotating ring-disk electrode (RRDE) demonstrated that the catalyst follows a two-electron oxygen reduction reaction (ORR) mechanism. The highest hydrogen peroxide electrogeneration was observed with 3% catalyst loading on graphene, achieving a yield of 90% H_2O_2. These findings suggest that the developed catalyst can efficiently produce hydrogen peroxide *in situ*, with potential application in the degradation of emerging contaminants.

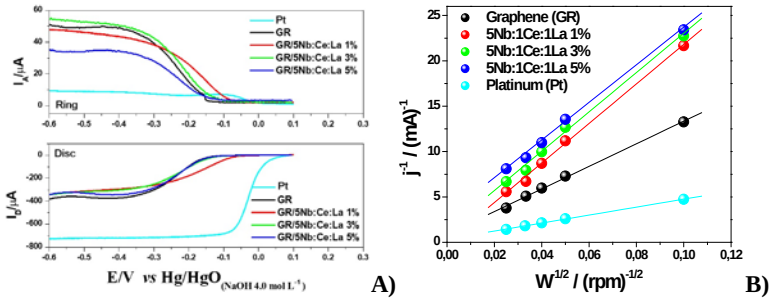

Table 1: Electrogenerated H_2O_2 and electrons number (η) transferred.

Material	*%H_2O_2*	*η*
Pt	10	3.9
GR	64	2.7
1% (5Nb:1Ce:1La)	69	2.8
3% (5Nb:1Ce:1La)	90	2.2
5% (5Nb:1Ce:1La)	82.9	2.5

Fig. 1: (A) ORR polarization curves; **(B)** Koutecky-Levich (K-L) plot.

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