NiO/Co_3O_4 composite: A noble-metal free bifunctional catalyst for oxygen evolution and oxygen reduction reactions

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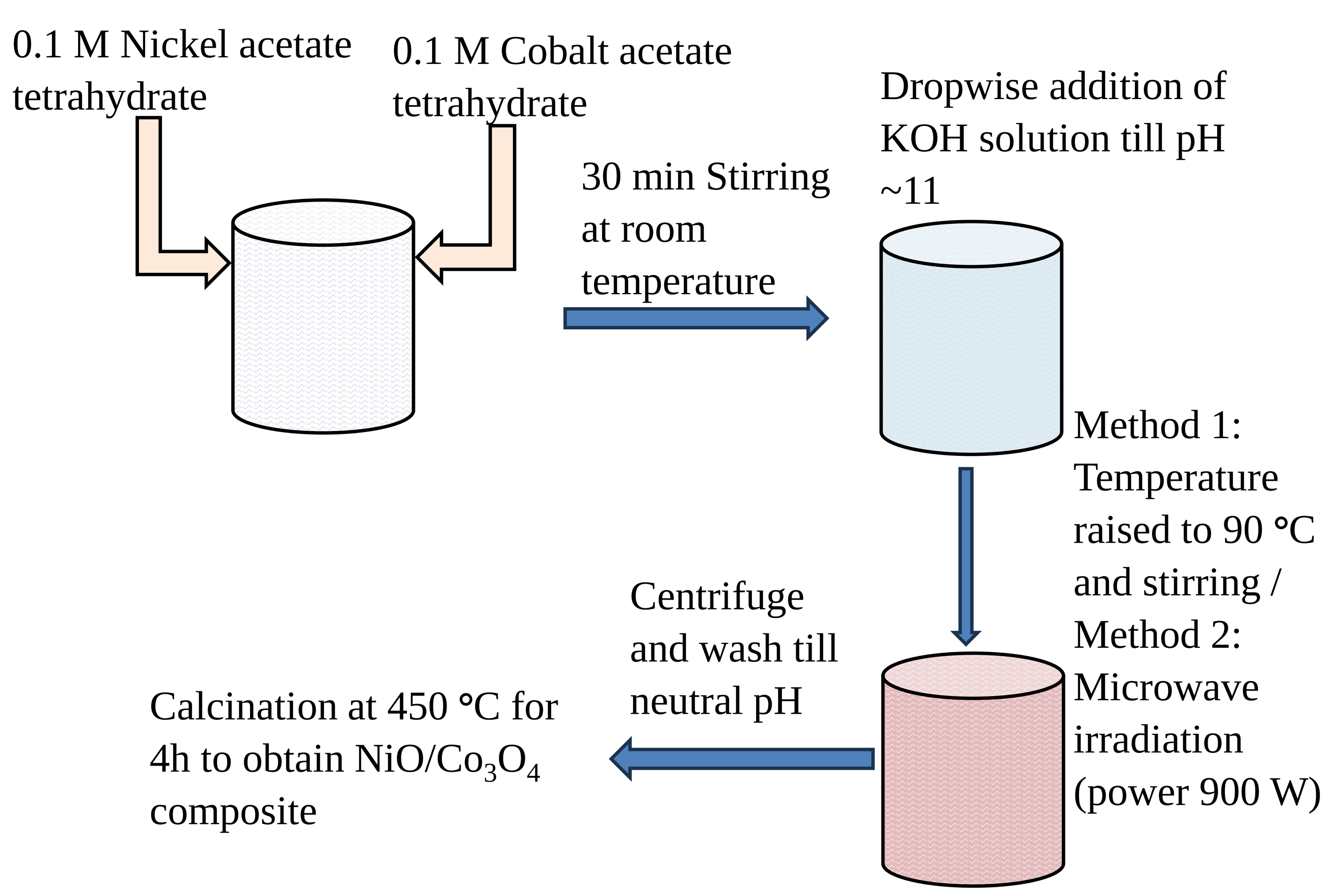
INTRODUCTION & AIM

- Oxygen electrochemistry is of significant importance in the renewable energy sector, mainly for hydrogen-based energy.
- Oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) are the two notable reactions in the oxygen electrochemistry.
- ORR happens at the cathode side in the hydrogen-based fuel cell and it has been considered as the limiting step over the hydrogen oxidation reaction in the fuel cell due to its high overpotential and sluggish kinetics.
- OER happens at the anode side in the electrochemical water splitting process and the process is complex and kinetics are sluggish, it is considered as the rate limiting step in water splitting process than the hydrogen evolution reaction (HER).
- Platinum-based materials are excellent for ORR but have poor OER performance, while Ru- or Ir-based materials are excellent for OER but have poor ORR performance.
- Researchers have tried developing alloys/composites of Pt, Ru, Ir and used as a bi-functional catalyst for ORR and OER, but these noble metals are expensive and less abundant.
- Therefore, developing low-cost, earth-abundant materials for bi-functional applications (ORR and OER) is important for utilizing hydrogen-based renewable energy.
- Herein, we report a simple synthesis methods for the preparation of NiO/Co_3O_4 composite with acetates as precursors and the processing time was also less.

METHODS



RESULTS AND DISCUSSION

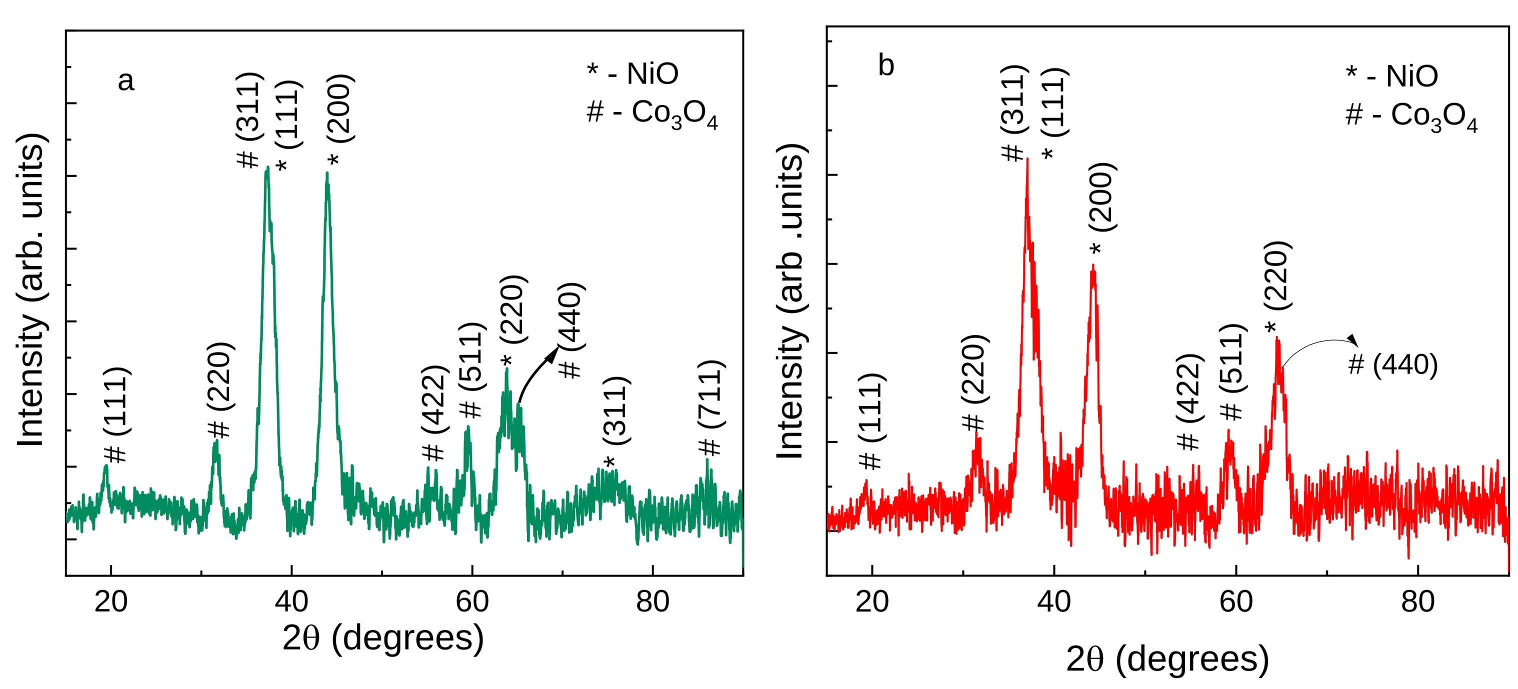


Fig. 1 XRD of NiO/Co_3O_4 composite prepared by two methods a. heating and stirring, b. Microwave

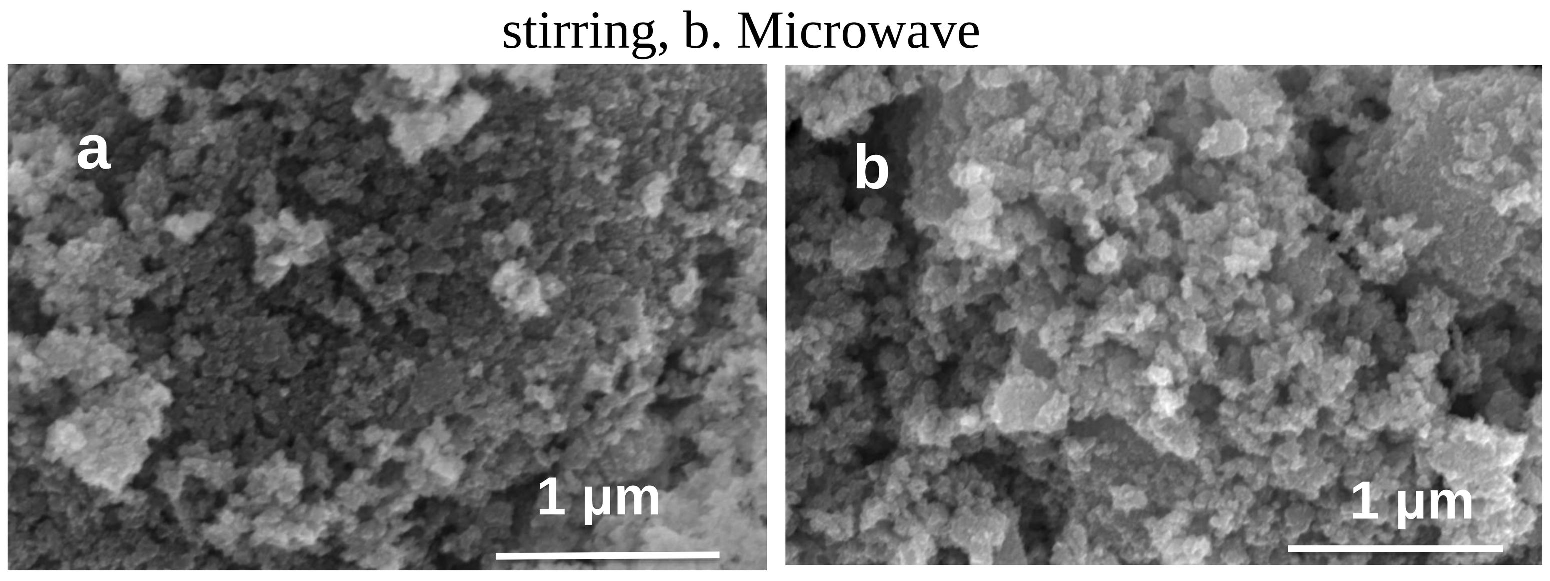


Fig. 2 FESEM images of NiO/Co_3O_4 composites prepared by two methods a. heating and stirring, b. Microwave

RESULTS & DISCUSSION

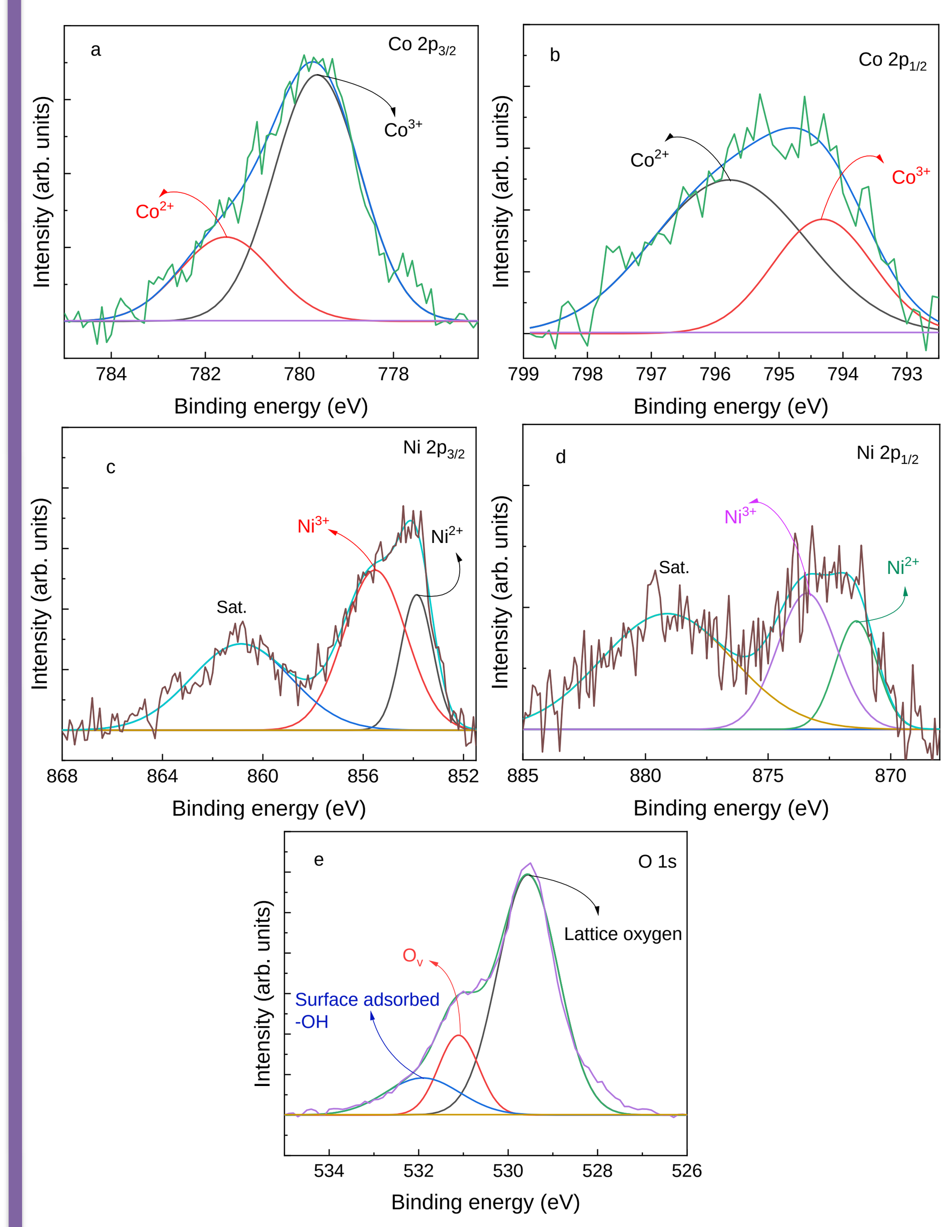


Fig. 3 XPS spectra of NiO/Co_3O_4 composite prepared by heating and stirring method

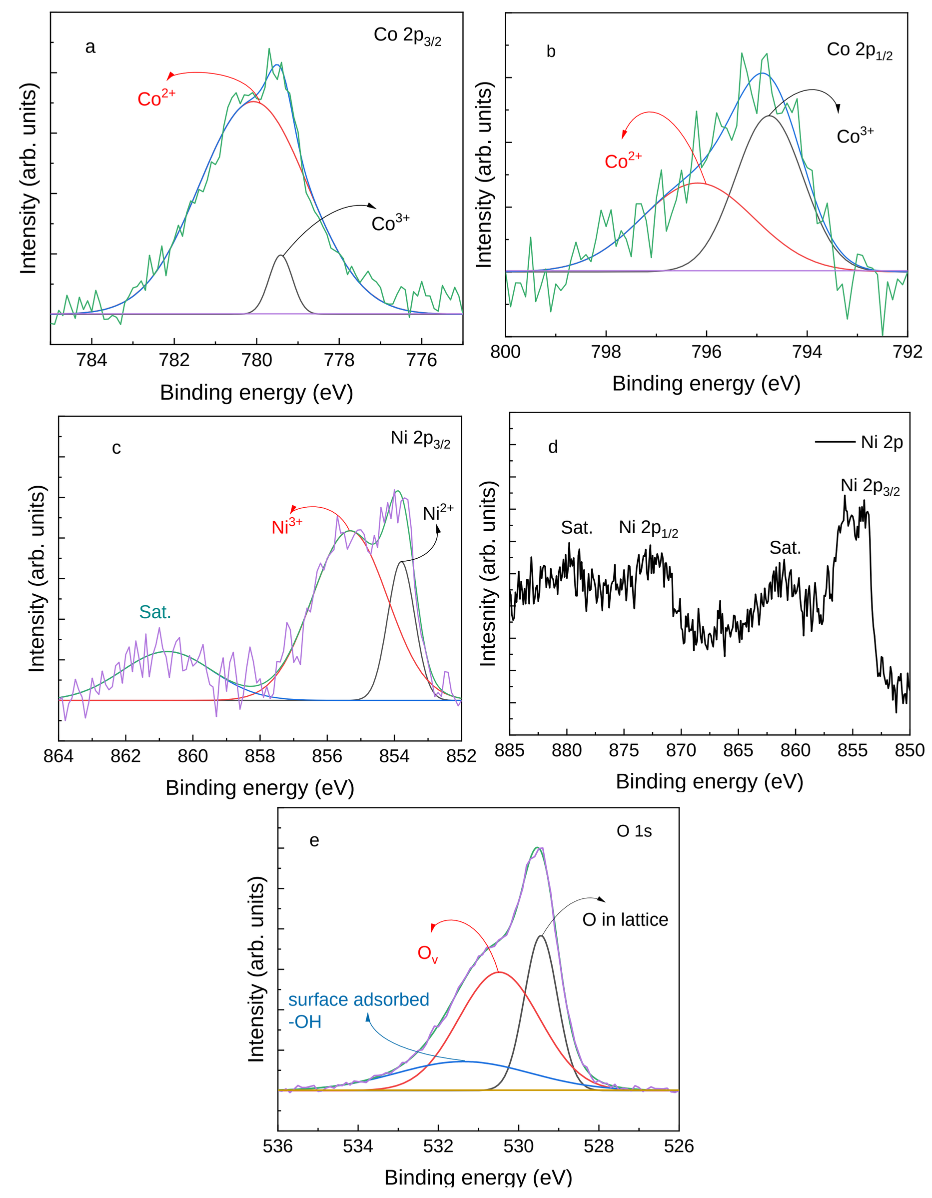


Fig. 4 XPS spectra of NiO/Co_3O_4 composite prepared by microwave method

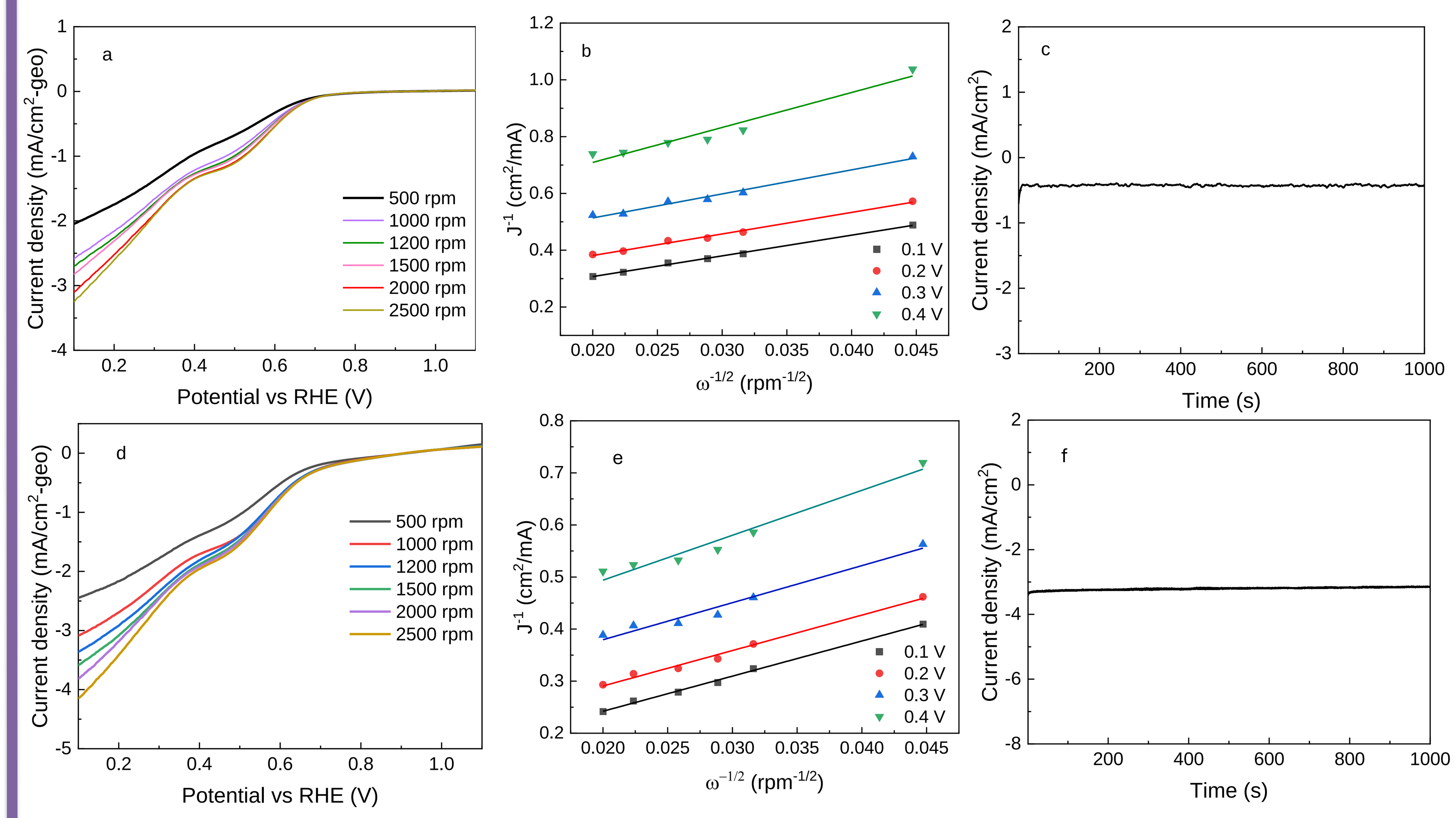


Fig. 5 a. Linear sweep voltammetry (LSV) plot of NiO/Co_3O_4 in oxygen saturated 0.1M KOH solution, b. KL plots, c. Chronoamperometry plot for stability test in O_2 saturated 0.1 KOH solution for the composite prepared by Method 1, similarly d-e plots are for the composite prepared by Method 2

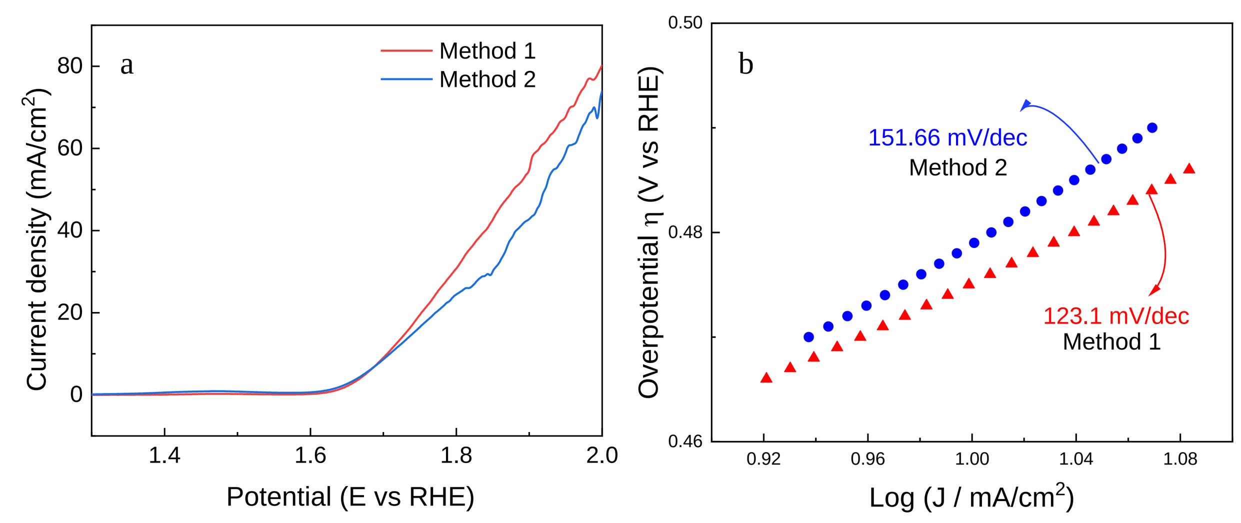


Fig. 6 a. OER polarization plots for NiO/Co_3O_4 composites in N_2 saturated 1M KOH prepared by two methods, b. Tafel slopes for two composites

CONCLUSIONS

- The NiO/Co_3O_4 composite was prepared by two methods method 1: heating and stirring method 2: Microwave irradiation.
- XRD confirms the formation of the NiO/Co_3O_4 composite, and the morphology of the composite was similar in both cases.
- XPS shows that there are abundant oxygen vacancies and Ni^{2+}/Ni^{3+} and Co^{2+}/Co^{3+} redox couples in the composite which are helpful for the OER and ORR.
- ORR onset potential of 0.703 V and 0.809 V vs RHE and OER offset potential of 0.476 V and 0.479 V was obtained for the composite prepared by method 1 and method 2.

ACKNOWLEDGEMENTS

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