

# How does cobalt doping concentration affect nickel hydroxide auxiliary electrode performance?

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Green hydrogen is considered to be an environmentally friendly alternative to fossil fuels. It can be used as an effective fuel due to its high energy density, but more importantly – it can be used for energy storage. Decoupled electrolysis makes hydrogen production safer, potentially cheaper and facilitates hydrogen delivery to end-users. Temporal and spatial decoupling of OER and HER requires a stable and effective mediator that can be repeatedly oxidized and reduced. Nickel hydroxide could be a good mediator; however, it suffers from limited stability and low conductivity,<sup>1</sup> furthermore, the potential at which Ni(OH)<sub>2</sub> is oxidized to NiOOH in basic media is very close to OER reduction potential. These problems can be remediated by doping with transition metals like cobalt.<sup>1</sup> Cobalt doping could lead to an increase in conductivity due to bandgap narrowing, possibly increased charge density, and charge redistribution that can impact the materials' redox potential.<sup>2</sup>

Five samples of Co-Ni(OH)<sub>2</sub>, where the molar ratio of Ni/Co was 1:0, 2:1, 1:1, 1:2, 0:1, were prepared via coprecipitation in alkaline media (NaOH<sub>aq</sub>). The characteristics of the powders were analysed using scanning electron microscopy (SEM), X-Ray diffraction (XRD) and X-Ray photoelectron spectroscopy (XPS).

The working electrodes were prepared by saturating carbon felt samples with electroconductive inks that were prepared by mixing the prepared powders with carbon black (*Vulcan X72*) and polyvinylidene fluoride (M<sub>w</sub> = 530 000), and dispersing this mixture in N,N-Dimethylformamide.

The electrochemical properties of the samples were evaluated using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and chronopotentiometry (CP).

Coprecipitated nickel hydroxide exhibits a high specific capacity of 153.13 mAh g<sup>-1</sup> (5 mV s<sup>-1</sup>). As long as nickel is in excess of cobalt, doping does not cause a significant decrease in capacity – at a molar ratio of 2:1 specific capacity is 147.56 mAh g<sup>-1</sup> (5 mV s<sup>-1</sup>), but at a ratio of 1:1 it is 138.97 mAh g<sup>-1</sup> (5 mV s<sup>-1</sup>). Cobalt doping allows the transition between Ni(OH)<sub>2</sub> and NiOOH to occur at a lower potential (Figure 1), thus possibly allowing to operate the working electrode at a potential at which no parasitic gas evolution can occur.

Samples with a higher cobalt concentration show a higher electrical double layer capacity – this could mean that the electrode can be charged and discharged more rapidly and it might be more durable.<sup>3</sup> Preliminary results indicate that the cycle time and capacity of undoped nickel hydroxide fall rapidly over prolonged cycling. The addition of cobalt improves the cyclability of the electrode, as mentioned in prior articles.<sup>1</sup>

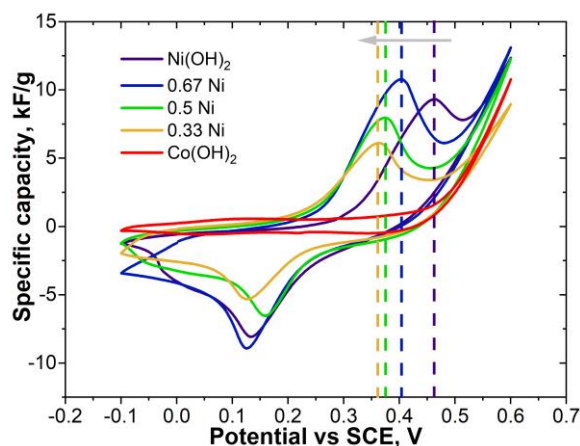


Figure 1. Cobalt doping effect on nickel hydroxide oxidation potential

## References

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