Electronic Supplementary Material (ESI) for Nanoscale.

Electronic Supplementary Information

Effects of Morphology and Chemical Doping on Electrochemical Properties of Metal Hydroxides in Pseudocapacitors

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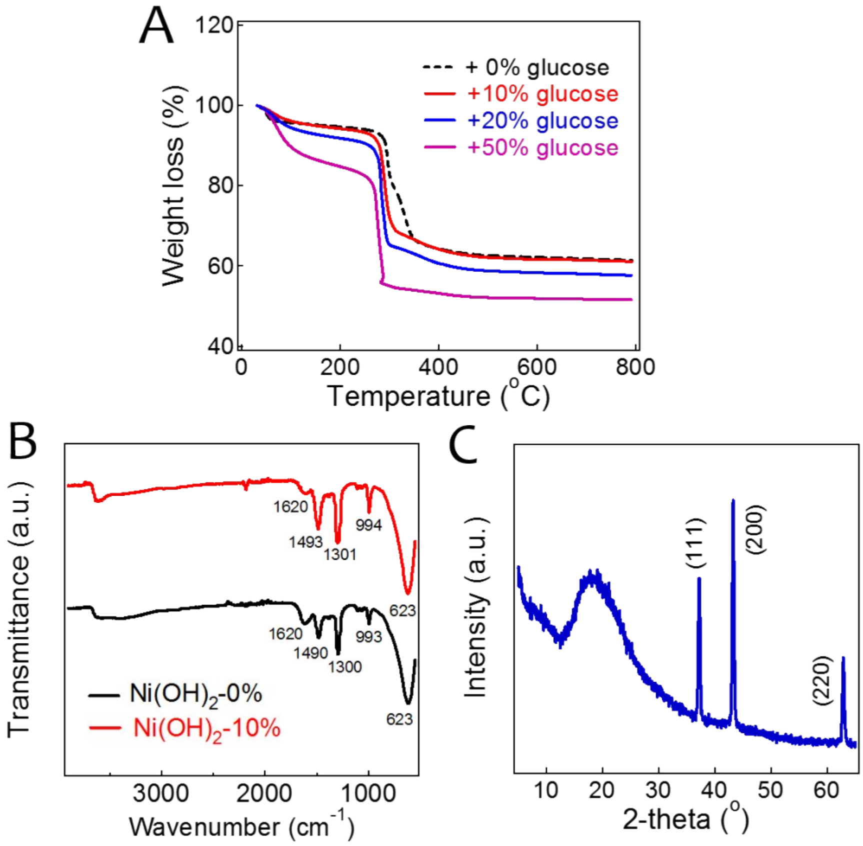

Figure S1: (A) TGA curves of Ni(OH)$_2$ synthesized with different concentration of glucose. The starting point for conversion into NiO shifted to lower temperature as the concentration of glucose increased. This is because crystallinity becomes poor and hydroxyl groups are loosely bound to Ni center in Ni(OH)$_2$ synthesized with glucose. Thus, the bond between Ni center and hydroxyl group easily breaks. (B) FTIR spectra of Ni(OH)$_2$ synthesized without glucose (black) and Ni(OH)$_2$ synthesized with 10% glucose (red). The broad bands around 3450 cm^{-1} are originated from the stretching vibration of hydroxyl groups and water molecules.[1,2] The band around 1600-1640 cm^{-1} is attributed to δH_2O vibration.[2] The band at 623 cm^{-1} corresponds to δOH vibration.[2] Two peaks at 1490 and 1300 cm^{-1} are related to the ν_3 vibration mode of NO_3^-.[2] The peaks correspond to C-H or C-C groups (2800-2900 cm^{-1}) were not observed,[1] implying that the absence of ethanol or glucose molecules in the Ni(OH)$_2$ host lattice. (C) XRD pattern of the sample after TGA, which corresponded to that of NiO.

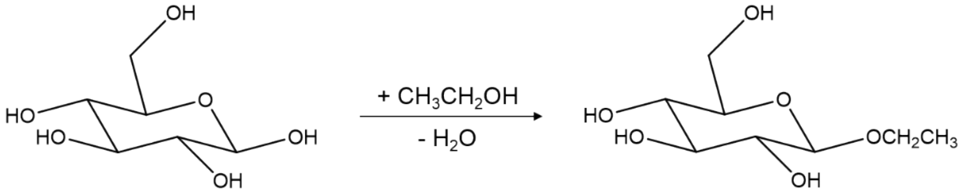

Figure S2: Reaction between ethanol and glucose during solvothermal synthesis. The most reactive hydroxyl groups are substituted by ethoxy groups via a dehydration reaction.

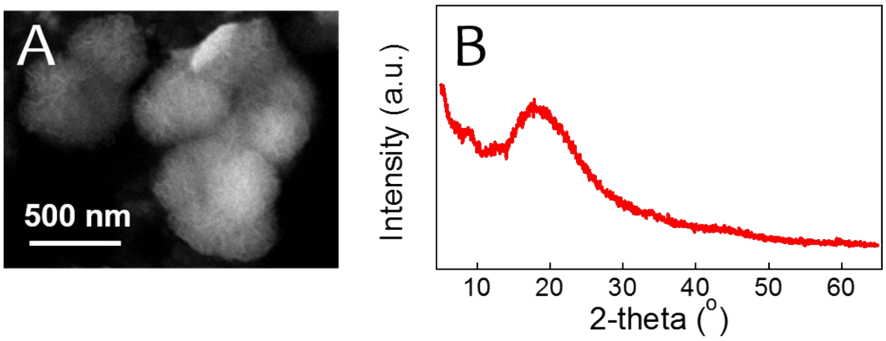

Figure S3: (A) SEM image and (B) XRD pattern of $Ni(OH)_2$ synthesized through two-step solvothermal process to verify the proposed mechanism of morphology modification by glucose.

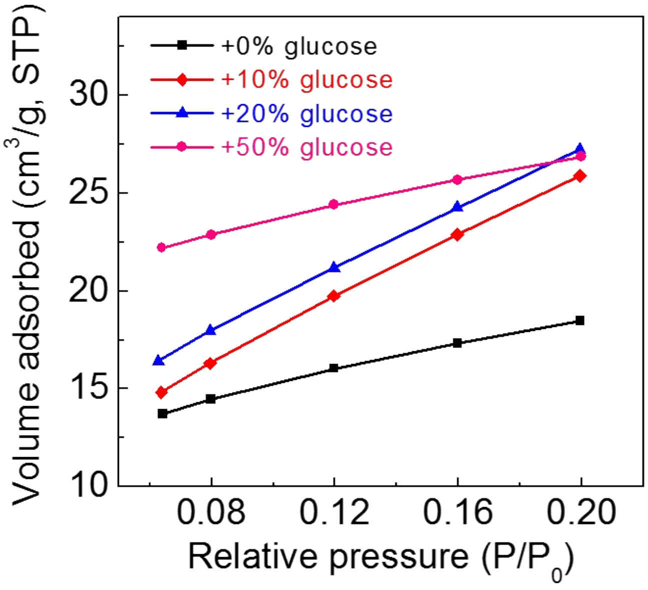

Figure S4: Nitrogen adsorption isotherms of $Co_xNi_{1-x}(OH)_2$ synthesized with different amounts of glucose.

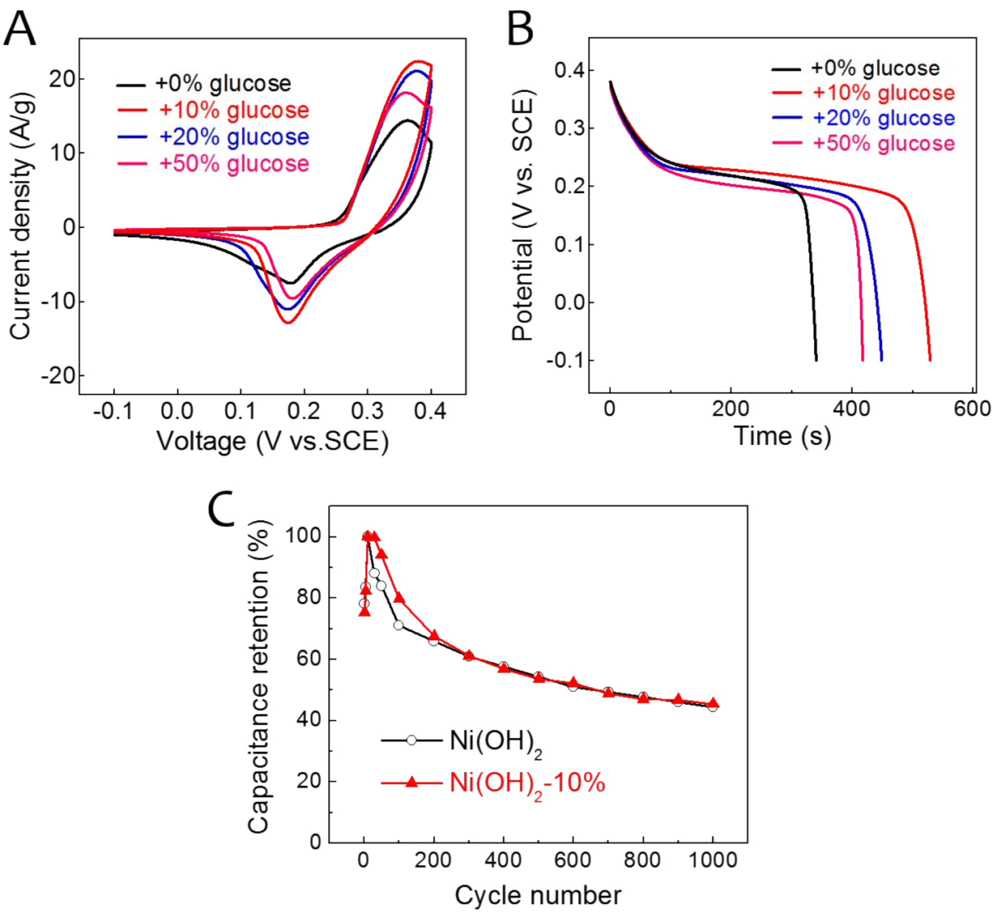

Figure S5: Comparisons of (A) CV curves and (B) galvanostatic discharge curves of $Ni(OH)_2$ synthesized with different amounts of glucose. (C) Comparison of cycle stability of $Ni(OH)_2$ synthesized without glucose and $Ni(OH)_2$ synthesized with 10% glucose using CV conducted at a scan rate of 50 mV/s for 1,000 cycles.

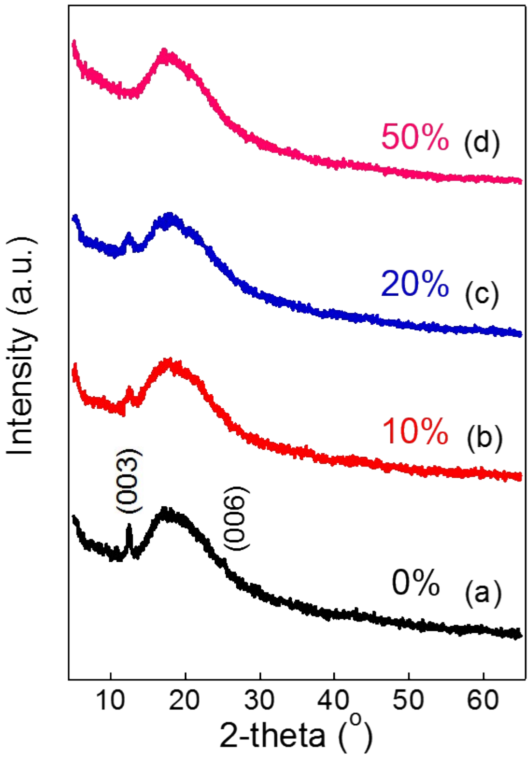

Figure S6: XRD pattern of $Co_{0.5}Ni_{0.5}(OH)_2$ synthesized with (a) 0%, (b) 10%, (c) 20%, and (d) 50% glucose additions.

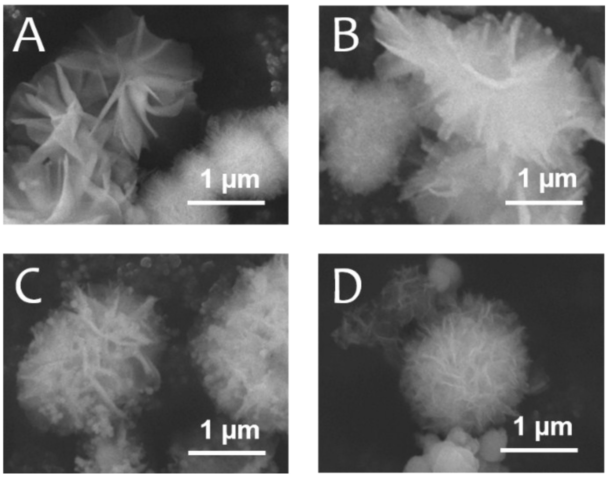

Figure S7: SEM images of $Co_xNi_{1-x}(OH)_2$ when x is (a) 0.3, (b) 0.5, (c) 0.7, and (d) 1 synthesized without glucose.

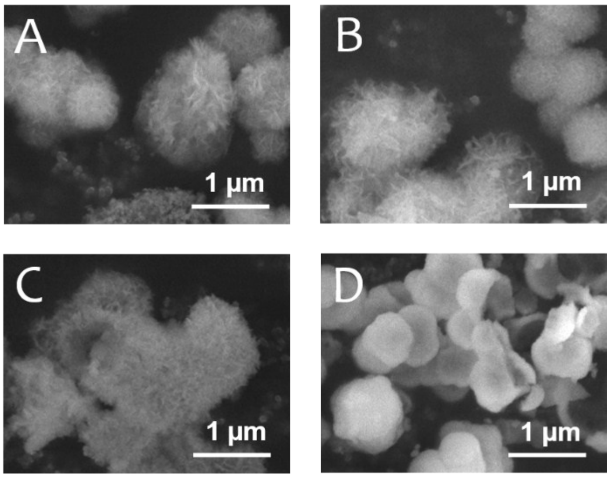

Figure S8: SEM images of $Co_xNi_{1-x}(OH)_2$ when x is (a) 0.3, (b) 0.5, (c) 0.7, and (d) 1 synthesized with 20% glucose addition.

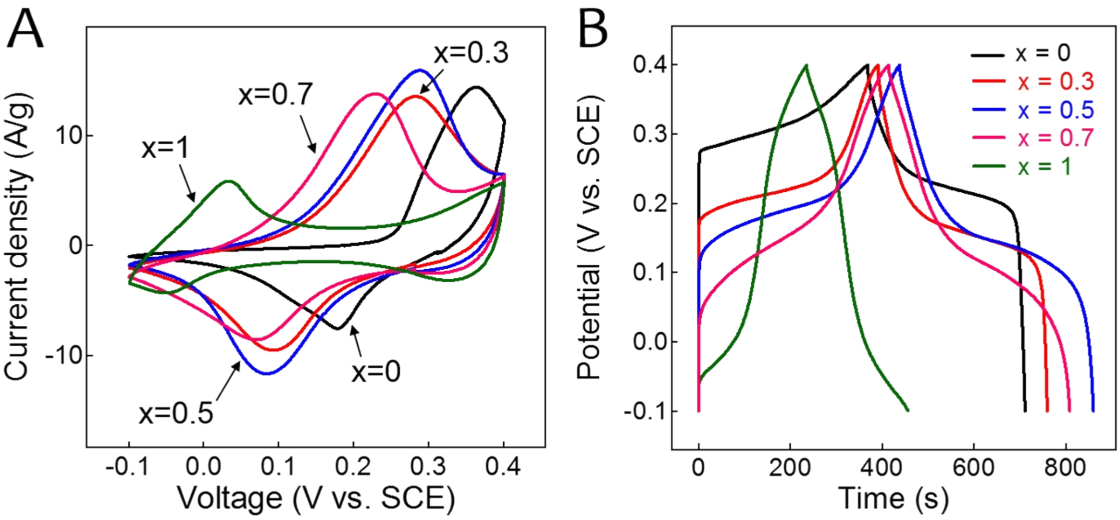

Figure S9: Comparisons of (A) CV curves and (B) galvanostatic charge-discharge curves of CoxNi1-x(OH)2 synthesized without glucose.

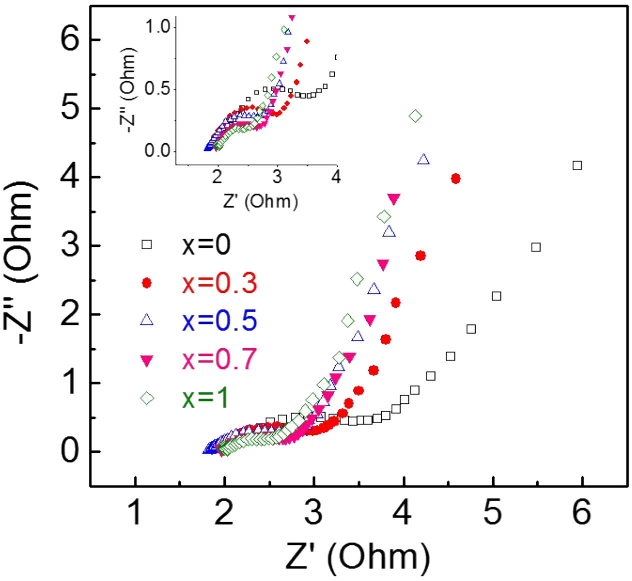

Figure S10: Nyquist plots of $Co_xNi_{1-x}(OH)_2$ synthesized without glucose.

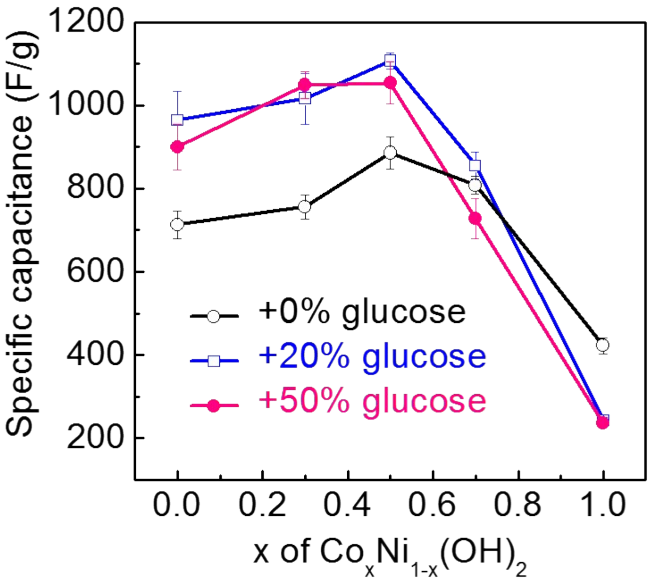

Figure S11: Comparisons of specific capacitance change as a function of x of $Co_xNi_{1-x}(OH)_2$. Each data point represents the average value of specific capacitance and error bars represent the standard deviation. The morphology control using glucose is more effective to improve the specific capacitance of Ni(OH)2 at low Co contents and becomes less effective at high Co contents.

Table S1: Comparisons of ESR values calculated from galvanostatic charge discharge curves and measured in Nyquist plots

Sample	ESR (Ω) Nyquist	ESR (Ω) CD curve
$Ni(OH)_2$-0%	3.7	3.8
$Ni(OH)_2$-10%	2.3	2.4
$Ni(OH)_2$-20%	2.7	2.7
$Ni(OH)_2$-50%	3.1	3.1
$Co_{0.3}Ni_{0.7}(OH)_2$	3.1	3.1
$Co_{0.5}Ni_{0.5}(OH)_2$	2.9	2.9
$Co_{0.7}Ni_{0.3}(OH)_2$	2.7	2.8
$Co(OH)_2$	2.5	2.5
$Co_{0.3}Ni_{0.7}(OH)_2$-10%	2.5	2.4
$Co_{0.5}Ni_{0.5}(OH)_2$-10%	2.5	2.5
$Co_{0.7}Ni_{0.3}(OH)_2$-10%	2.2	2.1
$Co(OH)_2$-10%	2.2	2.2

The ESR values were estimated using the extrapolation of the high x-intercept of curves in Nyquist plots and calculated from galvanostatic charge-discharge curves using the equation of ESR (Ω) = $\Delta V / \Delta I$.

ΔV = voltage drop at beginning of the discharge (V)

$\Delta I = |Icharge| + |Idischarge|$ (A)

References

1. K. H. Lee and S. H. Byeon, *European Journal of Inorganic Chemistry*, 2009, 929-936.
2. M. Taibi, S. Ammar, N. Jouini, F. Fie´vet, P. Molinie and M. Drillon, *Journal of Materials Chemistry*, 2002, **12**, 3238-3244.