Binary NiCoO$_2$-modified graphite felt as an advanced positive electrode for the vanadium redox flow battery

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Fig. S1: XRD spectra of GF, NiO/GF and CoO/GF.
Fig. S2: SEM images of (a) NiO/GF, (b) CoO/GF.
<table>
<thead>
<tr>
<th>Element</th>
<th>Spectrum 3 Wt%</th>
<th>Spectrum 3 Atomic%</th>
<th>Spectrum 4 Wt%</th>
<th>Spectrum 4 Atomic%</th>
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<td>43.45</td>
<td>42.58</td>
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<tr>
<td>Total</td>
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**Fig. S3:** EDX analysis of NiCoO$_2$ nanoparticles.
Fig. S4: Cyclic voltammograms of GF, TGF, NiO/GF and CoO/GF electrodes at a scan rate of 2.5 mv s⁻¹ in 0.2 M VOSO₄ + 2 M H₂SO₄.
**Fig. S5:** Cyclic voltammograms of GF, TGF, NiO/GF, CoO/GF and NiCoO$_2$/GF electrodes at a scan rate of 1, 2.5, 5 and 10 mv s$^{-1}$ in 0.2 M VOSO$_4$ + 2 M H$_2$SO$_4$. 
For an irreversible and quasi-reversible redox reaction, the diffusion coefficient can be calculated according to Equation S1:

\[
    i_p = 2.99 \times 10^5 \alpha^{1/2} n^{3/2} A C D^{1/2} v^{1/2}
\]

(Equation S1)

where \(i_p\) is the peak current density, \(n\) is the electron transfer in redox reaction, \(A\) is the surface area of the working electrode, \(C\) is the concentration of redox species in the electrolyte, \(D\) is the diffusion coefficient, \(v\) is the scan rate and \(\alpha\) is the charge transfer coefficient.

Fig. S6: Nyquist plots of GF, TGF, NiO/GF and CoO/GF electrodes in 0.1 M VO\(^{2+}\) / 0.1 M VO\(_2^+\) in 2 M H\(_2\)SO\(_4\).
Fig. S7: Schematic of the key components of VRFB (A) flow frame plate (B) graphite felt (C) membrane and the cell performance of charge-discharge of the flow cells employing GF and CoO/GF electrodes at a constant current density of (a) 75 mA cm\(^{-2}\) (b) 100 mA cm\(^{-2}\) (c) 125 mA cm\(^{-2}\) (d) 150 mA cm\(^{-2}\).
**Fig. S8**: Charge-discharge of the flow cell employing NiCoO$_2$/GF electrode. After 50 cycles, the electrolyte was refreshed using newly prepared solutions.
Fig. S9: SEM images of (a) NiCoO$_2$/GF before charge-discharge cycling; (b) NiCoO$_2$/GF after cycling.