A high voltage Vanadium-Metal Hydride (V-MH) hybrid rechargeable semi-flow battery utilizing electrochemical neutralization energy\cite{1-6} was proposed to implement as effective electrochemical energy storage system from intermittent energy sources like wind and solar energy. This V-MH semi-flow battery consists of graphite felt positive electrode in flowing VOSO$_4$-H$_2$SO$_4$ electrolyte and metal hydride negative electrode in KOH, the two pH differential electrolytes are separated by a bipolar membrane (as shown in Fig.1). Theoretically, it can deliver an overall cell capacity of 110 mAh/g, cell voltage of 1.8 V, and a much higher specific energy of 200 Wh/kg than that of the conventional all vanadium redox flow (VRF) battery. The high voltage (1.8 V) reported is among the highest in the aqueous Vanadium-based flow systems, about 40% higher than those of conventional VRF battery (1.26 V) and nickel metal hydride battery (1.25 V).

In most flow battery systems, the separator/membrane is used to prevent physical shorting of the electrodes, and diffusion of the active species in the electrolyte solution, but permeable to the charge carriers. In this V-MH semi-flow battery, the membrane must serve well as a barrier to prevent bulk neutralization. A stable charge/discharge behavior was obtained when using a bipolar membrane, as shown in Fig.2. This bipolar membrane is the main component limiting the power density due to its thickness (c.a. 1 mm), resulting in a high internal resistance (voltage drop). Further improvement of this system is expected with optimization in electrolyte concentration, flow rates, membrane thickness, or other cell and operation parameters.

Fig. 1 Set-up and components of the Vanadium-Metal Hydride (V-MH) hybrid semi-flow battery.

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Fig. 2 Ten charge/discharge cycles of the V-MH battery. V1 is the potential difference between the positive graphite felt (GF) electrode and the Hg/Hg$_2$SO$_4$ reference; V2 is the potential difference between the negative MH$_x$/MH$_{x-1}$ electrode and the Hg/HgO reference electrode; V3 is the voltage across the bipolar membrane measured by the Hg/Hg$_2$SO$_4$ reference electrode and the Hg/HgO reference electrode; V4 is the cell voltage which is the potential difference between the GF electrode and MH$_x$/MH$_{x-1}$ electrode.\cite{6}

References:

\textit{This is an example of a clear and concise scientific study. The authors have presented a detailed description of their research, including the theoretical background, experimental setup, and results. The references are well-cited, and the conclusions are supported by the data presented.}