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Influence of Cell Geometry and Operating Parameters on Performance of a Redox Flow Battery with Serpentine and Interdigitated Flow Fields

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In recent years, the development of a variety of energy storage devices have been carried out. Redox flow batteries (RFBs) are one of these candidates as a large-scale and long-term energy storage system. In RFBs, electrolyte with active materials is supplied to each electrode. Accordingly, increasing the storage capacity is easily implemented by increasing the stored volume of the electrolyte. No noble metal catalyst is needed for electrode reaction and reuse of active materials from the system is readily achieved [1]. However, improvement of power density is one of the technical challenges, which hinders the practical use. Recently, RFBs with serpentine channels imitating hydrogen fuel cell geometry have been reported [2], showing drastic increase in the cell performance. On the other hand, interdigitated channels has been proved for effective supply of active material to the electrodes [3].

In this study, we assembled a Vanadium Redox Flow Battery (VFRB) to investigate an effect of channel geometry and electrode properties on cell performance. We examined both serpentine channel and interdigitated channel affecting discharge behaviors in VFBRs with different carbon electrode applied. We also investigated effects of active material and proton concentration provided to the cell on discharging behaviors.

Figure 1 shows the unit cell structure of a flow battery we assembled. The cell consists of end plates, current collectors, gaskets, electrodes, and a proton exchange membrane (PEM). Different flow channels, *i.e.* serpentine and interdigitated geometry, are grooved in the end plate. In this study, we performed our experiments using Nafion®117 ((178μm thick, 1,100g/mol equivalent weight, DuPont) as the PEM, but we also used Nafion® 115 and 212 to examine effects of membrane thickness on cell performance. Two different carbon electrode materials, carbon paper (SGL carbon, 25AA, 190μm) and carbon felt (SGL carbon, 10AA, 390μm) were applied to the cell.

Figure 2 shows effects of acid concentration on performance of the VRFB with an interdigitated flow field. Cell performance was greatly improved by using highly-concentrated acid, showing that ionic transport loss is a dominating factor to determine cell performance.

The interdigitated flow field in our VRFB showed better performance than the serpentine flow field as shown in Fig.3. This has been explained by convective transport of active material to the electrode. We observed a higher cell performance with the interdigitated flow field and the carbon felt electrode. This could be attributed to thickness of the electrode, i.e. surface area. The carbon felt electrode was thicker than the carbon paper electrode, resulting in higher surface area of the electrode. This gives rise to better cell performance with carbon felt electrode.

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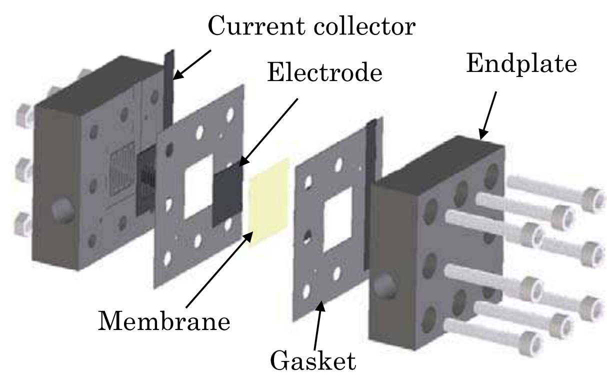

Figure 1 Schematic of a flow battery used in this study.

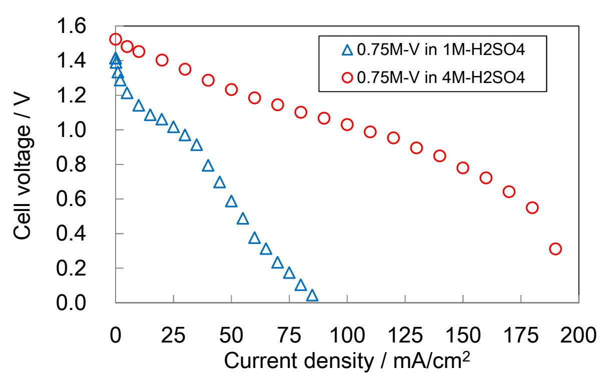

Figure 2 Performance curves of the flow battery with an interdigitated flow field with different acid concentration.

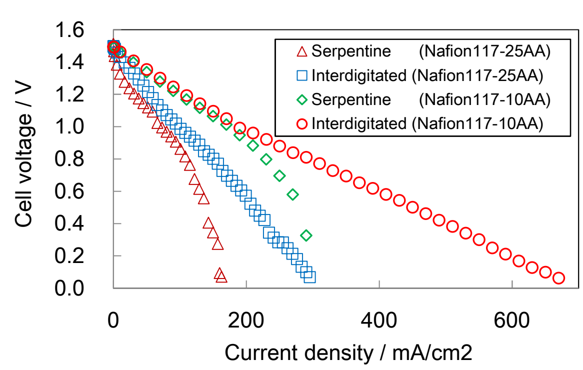

Figure 3 Performance curves of the flow battery with different carbon electrode and channel geometry. Initial Vanadium ion concentration was 1.5mol/L