Materials development of vanadium flow battery: challenge and prospective

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Renewable energies from sources like solar and wind are among the central topics of our times with the concerns of energy shortage and environment protection. However, the random nature of these intermittent renewable sources (change with synoptic conditions, day and night alternation, etc.) makes it quite challenging for its use and dispatch through the grid. One effective solution is to connect the power station and the grid with electrical energy storage devices.

Vanadium flow battery (VFB) is one of the most suitable candidates for large-scale energy storage due to its advantages like high safety, excellent stability, high efficiency, long cycle life and low cost, etc. Numerous application demonstrations illustrated that VFB can meet the demands of large-scale energy storage and is suitable for the applications like renewable energy generation and the distributed energy supply etc. However, the relatively low power density of VFB leads to its too high cost and further hinders its further commercialization. Therefore significant efforts were made to further lower the VFB cost by exploring key materials with improved performance. The key materials of a VFB mainly include the electrolyte, the carbon felt electrode and membranes.

Dalian Institute of Chemical and Physics (DICP) has devoted to VFB research for more than 10 years from materials to system integration. The key materials including electrolytes, electrodes and membranes were successfully explored and realized mass production via investigating the structure-performance relation of the materials (Figure 1).

Figure 1. Key materials development in DICP

For the electrolytes, the transfer behavior of electrolytes were clarified via investigating the transfer behavior in membranes with different morphologies, the results showed the capacity decay rate of VFB could be lowered via changing membranes materials (Figure 2).

Figure 2. The transfer of vanadium electrolytes through membranes with different side chains

For the bipolar plates, the concept of carbon composite bipolar plate was proposed and the batched preparation techniques and continuous modeling equipments for carbon composite bipolar plate were established, where the production capacity has reached 20,000 m²/year. Meanwhile, porous membrane separator was first introduced into VFB based on the idea of separating vanadium ions from proton via pore size exclusion (Figure 3). This new concept successfully overcomes the restriction caused by ion exchange groups from traditional ion exchange membranes, which broadens the materials option of VFB membranes. And the membrane structure was optimized via investigating the structure-performance relationship and the ion-transport mechanism for VFB membranes.

Figure 3. The principle of porous membrane in VFB application

In this presentation, the research on VFB key materials will be introduced and the progress of key materials in DICP will be presented.

References: