Karlsruhe Institute of Technology

Institute for Inorganic Chemistry
Institute for Applied Materials

Electrochemical activity of different carbon materials for all-V redox flow batteries

Johannes Öhl[1], Julia Melke[1], Christina Roth[1,2]

[1] Karlsruher Institut für Technology, [2] Freie Universität Berlin

Introduction

Vanadium-redox-flow batteries (VRBs) are a promising technique in electrochemical applications. While many battery types use conversion from dissolved to solid substrate, the Vanadium in VRBs is always dissolved (Figure 1). However electrode materials with higher electrocatalytic activity will improve the performance of the system. Therefore, our work aimed at testing carbon materials for their use in VRBs regarding their electrochemical activity and correlating it to their respective structures.

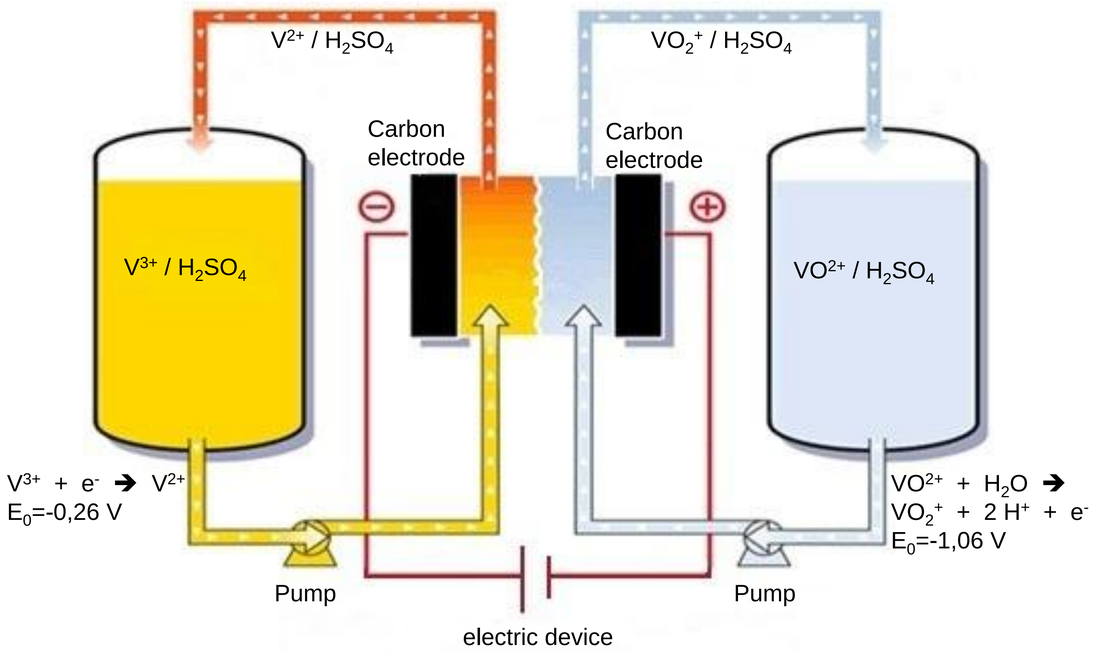

Figure 1: Set-up of a VRB.
*(*http://www.pdenergy.com/products_whatisvrb.html)

Cyclic voltammetry of carbon electrode materials

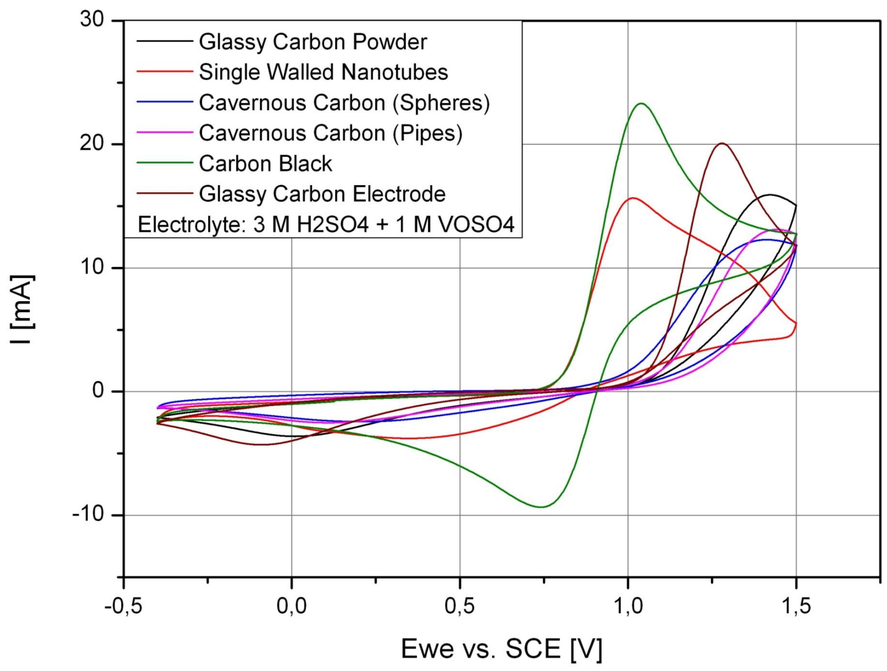

Figure 2: Cyclic voltammetry of the investigated carbon materials prepared on a glassy carbon electrode. The smallest onset-potentials are shown by Carbon Black and Single Walled Nanotubes, Carbon black also has got the highest current and best reversibility. The special cavernous carbons are no significant improvement compared to the empty glassy carbon electrode.

REM measurements

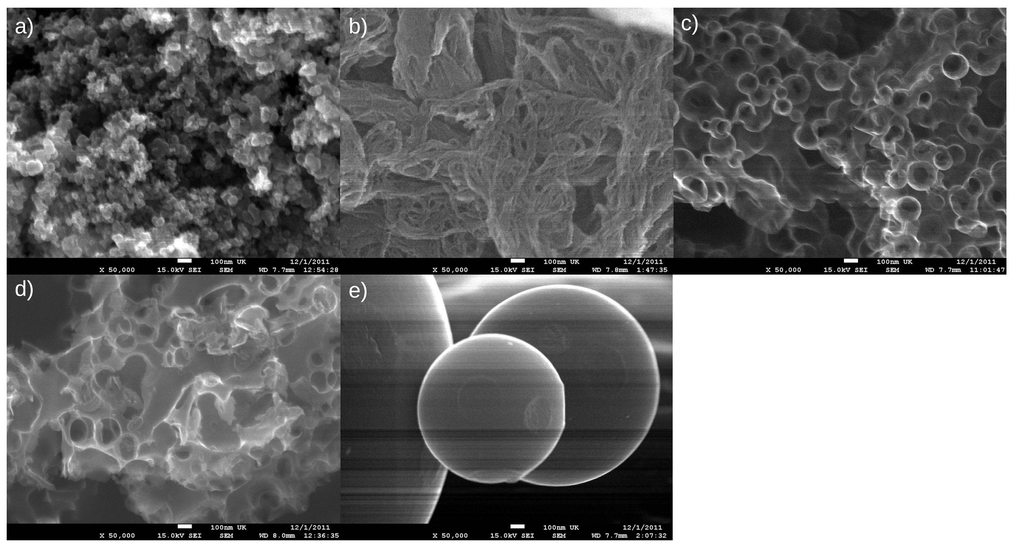

Figure 3: REM-measurements of: a) Carbon Black, b) single walled nanotubes, c) spherical cavernous carbon, d) pipe-shaped cavernous carbon and e) glassy carbon powder, each 50.000 x enlarged. Carbon Black and Nanotubes are forming the smallest structures with particles and strings, respectively, of about 50 nm in diameter. The cavernous carbon contains spheres and pipes with a diameter of about 100nm in diameter. The glassy carbon spheres are quite big with diameters from 1 µm.

BET measurements

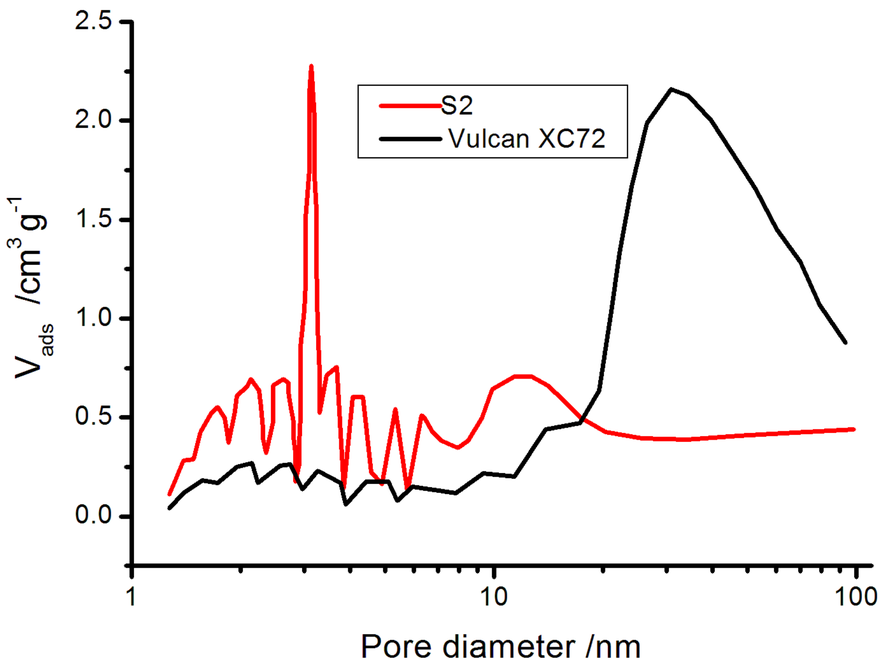

Figure 4: BET measurements of Carbon Black and spherical cavernous carbon show that the cavernous spheres have twice the specific surface area than carbon black, but less total pore volume.

Conclusions

Regarding the results of the different measurement methods, it seems that electrochemical activity is provided by small particle size and large pore volume. Therefore, Carbon Black reaches best activities, while the cavernous carbon only shows low activity despite its large surface.