Materials Science-2013

OMICS Group Conferences
Accelerating Scientific Discovery

2nd International Conference and Exhibition on
Materials Science & Engineering

October 7-9, 2013 Hampton Inn Tropicana, Las Vegas, USA

Hierarchical nanoporous carbon architectures for super capacitor applications

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Abstract

Supercapacitors with high power density in combination with batteries with high energy density can lead to efficient energy storage systems. Recent studies from NREL have shown that HEVs equipped with 40-100 Wh/kg supercapacitors could improve the fuel efficiency by 15-30%. However, energy density of state-of-the-art capacitors (2-20 Wh/kg) is an order of magnitude lower than metal hydride (40-100 Wh/kg) and Li-ion batteries (120-170 Wh/kg). The key scientific barrier for low capacitances is the presence of micropores on the active surface of electrodes that are not accessible to electrolytes. Although there are a few exceptions, it has been widely accepted that high surface area materials with pores substantially larger than the size of solvated ions in the electrolyte is a prerequisite for achieving high capacitances. Research efforts are focused on increasing active surface area, pore size control and increasing operational voltage by use of ionic liquid electrolytes. Hybrid carbon based materials with enhanced electrolyte accessibility could serve as potential alternatives which requires precise control of pore sizes and presents a grand challenge. We will present our results on controlled synthesis and electrochemical studies of hierarchical nanoporous carbon architectures derived "metal organic frameworks (MOFs)". MOFs represent a new class of materials with well-defined porosity, structure tailorability and tunable functionality with considerable attention due to their promise in wide range of applications. Porous carbons derived from MOFs (CMOFs) exhibited high surface area, porosity and pore volume. To further improve the overall electrical conductivity of CMOFs, heteroatoms such as nitrogen can be introduced using amine linkers during MOF synthesis. The Brunauer-Emmett-Teller (BET) surface areas of the as-synthesized CMOFs are in the range 150-800 m2/g. Detailed synthesis strategies, effect of annealing temperature on the CMOFs structure and their electrochemical performances [Figure 1] as materials for supercapacitors will be discussed.

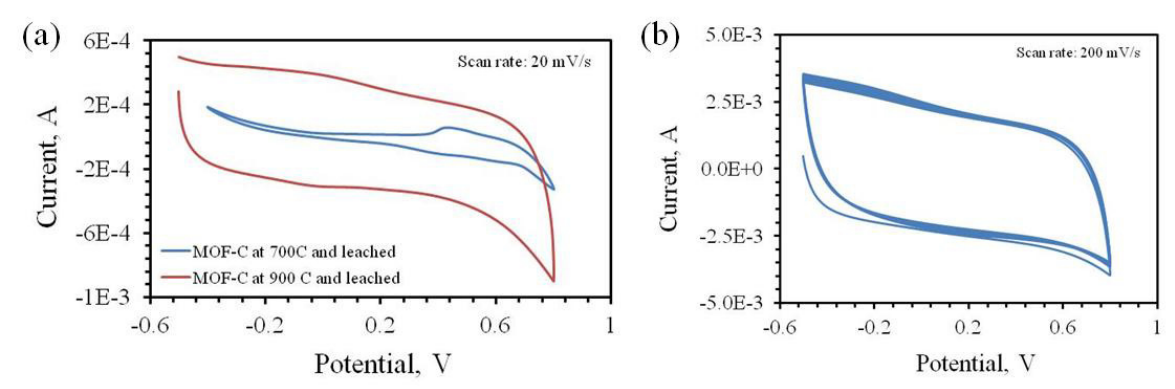


Figure 1: Cyclic voltammetry curves: (a) CMOFs annealed at 700 and 900 oC showing enhanced capacitance with annealing temperature increase. (b) 100 cycle data for CMOFs showing good cycling stability.