Nitrogen-Precursor Dependence of the Carbon Sponge Production

Cristina L. Rodriguez-Corvera, Emilio Muñoz-Sandoval, Florentino López-Urías*

[1]*Advanced Materials Division, IPICYT, Camino a la Presa San José 2055, Lomas 4a sección, San Luis Potosí, S.L.P., 78216, México.*

Abstract

Carbon sponge nanostructures were synthesized using the aerosol assisted chemical vapor deposition (AACVD) method involving the decomposition of a mixture of ferrocene ($C_{10}H_{10}Fe$), N-precursor, thiophene (C_4H_4S), and ethanol (C_2H_5OH) at 1020 °C under a flow of H_2/Ar. We used as nitrogen precursors, pyridine (C_5H_5N), acetonitrile (CH_3CN), urea (CH_4N_2O), benzylamine (C_7H_9N). Sample morphology and composition profiles were analyzed by SEM, TEM, XRD, XPS, FTIR, Raman spectroscopy, and TGA. We found that the carbon sponges morphologies depend strongly on the nitrogen precursor, for benzylamine precursor, the sponges are formed by corrugated carbon fibers with a bimodal diameter distribution. When urea and benzylamine were used as precursors, the sample contained carbon fibers with a zigzagging behavior with a bimodal diameter distribution. The carbon sponge made with pyridine and benzylamine precursors exhibited highly entangled wavy carbon fibers and Fe-based nanoparticles surrounded by graphite materials. The XPS characterizations revealed the presence of different nitrogen doping (N-substitutional, N-pyridinic, N-pyrrolic) and chemical functional groups (nitrogen oxide, amines, and amides). The carbon sponges exhibited an atomic concentration of 0.21-2 %. From a deconvolution analysis, it was found interesting trends for the high resolution XPS N1s and O1s core level. An estimation of the percentage derived from the deconvolution analysis revealed that N-pyrrolic doping, quinone, ester, and ether groups were dominates in all samples. The XRD characterization demonstrated the presence of non-symmetric peak for (002) crystallographic graphitic plane, suggesting the presence of slightly expanded graphite material. In addition, the absorption of hydrocarbons and electrochemical reactions of our carbon sponges were investigated.