Revelation of the influence of catalytic reduction process on the morphology and properties of CNTs/carbon fabrics and their composites

R J Lu[1], T Zhong[1], H L Wu[1], C Miao[1], L H Bai[1], W Yuan[1] and C G Wang[2]

1.Inner Mongolia Metal Material Research Institute, Baotou 014034, China
2.School of Material Science and Engineering, Shandong University, Jinan 250061, China

Introduction

Carbon fabrics reinforced composite is a special class of high-performance materials, which has high specific strength and stiffness, excellent corrosion resistance , and excellent designability. However, the surface inertness of the carbon fabric itself causes a weak bond with the matrix , resulting in the low interface strength and the damaged mechanical properties of the composite. One of the most competitive and promising methods is the direct growth of Carbon nanotubes (CNTs) on the surface of carbon fabrics by chemical vapor deposition (CVD), which aims to improve the interface bonding and the overall mechanical properties of the composites on the nanometer scale. In the whole process of CNTs growth by CVD, the catalytic reduction process is considered to play an important role. Different catalyst types and catalytic reduction temperatures will cause the catalyst particles to have different crystal structures, different particle sizes, and different catalytic activities, which will have different effects on the growth of CNTs. In this paper, the effects of catalyst types and catalytic reduction temperatures on the morphology and the mechanical properties of carbon fabrics and their composites were studied, and the mechanism was discussed.

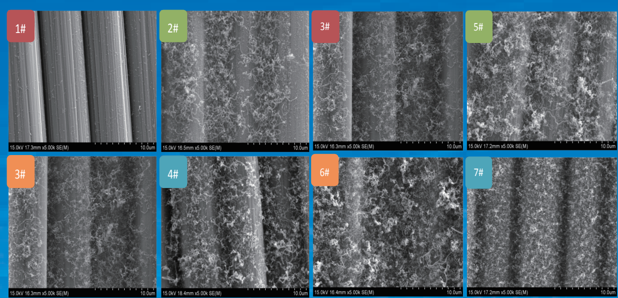
Experimental

The ethanol solutions of 0.05mol/L $Fe(NO_3)_2$•$9H_2O$ and 0.05mol/L $Co(NO_3)_2$•$6H_2O$ were prepared, and the two were mixed at a ratio of 1:0, 0:1, 1:1, and 2:1, respectively. The desized carbon fabrics were immersed in the different solutions mentioned above respectively, taken out and placed in the φ40 vertical CVD furnace after 10min. Keeping the furnace pressure at 0.01MPa, the reactor was heated to 450°C, 500°C, 550°C, or 600°C, and then the temperature was maintained for 0.5h with H_2 being passed in. During the process, the catalyst's nitrate precursors were reduced to metal nanoparticles, labeled as Fe, Co, Fe-Co, and Fe_2-Co, respectively. The temperature of reactor was subsequently raised to 600°C, and CNTs were synthesized directly on the surface of carbon fabrics by introducing a mixture of H_2, C_2H_2, and N_2 for 10 min, obtaining the CNTs/carbon fabrics reinforcements.

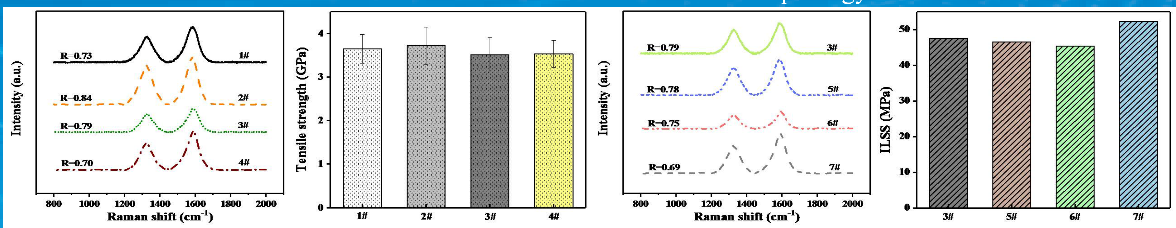
Results and Discussion

Specific parameters of all samples

Sample	Catalyst type	Reduction temperature(°C)
1#	Fe	450
2#	Co	450
3#	Fe-Co	450
4#	Fe_2-Co	450
5#	Fe-Co	500
6#	Fe-Co	550
7#	Fe-Co	600



Surface morphology of CNTs/carbon fabrics



(i) The catalytic activity of the bimetallic catalyst is higher than that of the single metal, and the surface uniformity of CNTs catalyzed by Fe-Co is the best.

(ii) When the reduction and growth temperatures are set to 600°C, the uniformity of CNTs and the ILSS of composites increase obviously. In the process of rising temperature, the nano-catalysts tend to aggregate in the direction of particle growth, so removing this process will help to improve the overall performance of CNT/carbon fabrics and their composites.