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In-situ Synthesis of Multiwall Carbon Nanotubes on Portland Cement Clinker

P. Ludvig[(1,2) *], L. O. Ladeira[(2) *], J. M. Calixto[(1)], I. C. P. Gaspar[(1,2)] and V. S. Melo[(1)]

(1) Department of Structural Engineering, Federal Univerity of Minas Gerais, Belo Horizonte, Brazil.
(2) Nanomaterials Laboratory, Department of Physics, Federal University of Minas Gerais, Belo Horizonte, Brazil.
* Corresponding authors: pludvig@eng-estrut.dout.ufmg.br, ladeira@fisica.ufmg.br

Abstract – Carbon nanotubes were grown by chemical vapor deposition on Portland cement clinker in order to produce a new composite material. The yield, size and morphology of carbon nanotubes grown were studied using clinker as support and catalyst. Iron sources such as iron ore, steel mill scale and red mud were used as additional transition metal catalyst to increase the carbon nanotube content. Yield was determined by thermogravimetric analysis, and scanning electron microscopy was used to characterize the size and morphology of nanotubes.

A novel nanocomposite of carbon nanotubes (CNTs) and Portland cement (PC) is being developed. This new material is based on the in-situ growth of multiwall carbon nanotubes (MWCNTs) using PC clinker as support of catalyst particles. A low cost process to produce large amounts of cement nanostructured with CNTs has been developed which can be adapted to conventional industrial cement plants [1].

CNT synthesis by chemical vapor deposition (CVD) is catalyzed by transition metal nanoparticles deposited on a thermo-stable support. PC clinker is the result of high temperature calcination of limestone and clay and thus is an ideal support for this purpose. The clinker contains tetracalcium aluminoferrite (C_4AF phase) which can be used as catalyst for CNT growth. In a CVD process using ethylene as carbon source and pure PC clinker at the same time for support and catalyst of CVD process we obtained a CNT yield of 4,03% in mass of clinker-CNT nanocomposite. In our goal to reduce production costs, we examined the possibility to attain better yield by raising the abundance of catalyst particles. Iron ore and industrial byproducts such as steel mill scale and red mud were added to the clinker in different proportions, which resulted in CNT yield increase to 10,40%. The additional iron sources had different effects on CNT growth yield due to differences in catalyst particle size and conformation. In all cases, thermogravimetric analysis (TGA) was performed to determine CNT yield. The peak between 480 and 600°C shows that the clinker-CNT composite contains high purity MWCNTs.

Beyond the yield some other important characteristics of the produced CNTs are size, morphology and aspect ratio. Scanning electron microscope (SEM) images of every sample clearly show the presence of CNTs. Meanwhile the addition of iron particles to clinker had an effect on CNT appearence. Figures 1 and 2 show typical CNT morphologies obtained.

With a simple physical mixture containing 0,3% of CNTs in cement matrix as described in [2], improvements in mechanical properties have already been obtained: 34,28% increase in the tensile strength. With this new method of synthesis, enhancements in the material behavior are expected to be higher due to better dispersion and bonding of CNTs to cement particles.

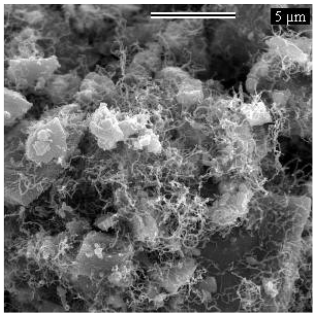

Figure 1: SEM image of CNTs grown on pure clinker (5.000x)

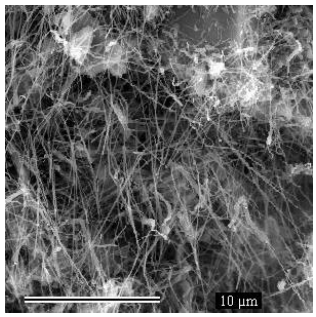

Figure 2: SEM image of CNTs grown on clinker and steel mill scale (4.000x)

References

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[2] Melo, V. S. "Nanotecnologia aplicada ao concreto: Efeito da mistura física de nanotubos de carbono em matrizes de cimento Portland" - Master's dissertation in Constructional Engineering, School of Engineering, Federal University of Minas Gerais, Belo Horizonte, 2009.