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Synthesis of Nano Carbon Onions by a Mechanical-Chemical Route

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Graphite-like carbon materials are known for their ability to form tubular, spheroid and lamellar structures [1]. Nano carbon onions (NCO) consist of concentric multilayered graphitic shells. This type of structure is related with the fullerene-family materials and carbon nanotubes [2]. These structures have gained great interest due to their novel properties and potential applications in various technology fields. Among these fields is the aerospace, energy, automobile, medicine, and chemical industry. Some examples of their applications include, gas adsorbents, templates, actuators, composite reinforcements, catalyst supports, and nano-reactors [3]. NCO preparation is performed by some different methods: arc-discharge, electron beam irradiation, CVD, radio-frequency, micro-wave plasma, annealing diamond nanoparticles [2], ball milling and chemical routes [1]. However, nowadays there is a growing interest in the preparation of these materials at low temperatures. Between these methods, the chemical–mechanical route is a versatile technique to produce this structure at room temperature starting from ordinary graphite.

In the present work, NCO structures were prepared using an alternative mechanical method followed with by a leaching process. Pure aluminum and graphite powders were used as raw materials. The mixture (1:1 in wt.) was milled in a high-energy mill (Spex) for 1h. The milled sample was then leached with an HCl solution (1:1 in vol.) in a ratio of 100ml/1g, washed with distilled water and dried at room temperature overnight. Morphological studies were performed with a high resolution transmission electron microscope JEOL JEM-2200FS equipped a C_s corrector in the condenser lens.

In Fig. 1 it is evident the presence of defects induced by the milling process, such as imperfect graphitic shells, spiral-like structure and vacancies in the graphitic layer.

In Fig. 2 is observed a zone with high density of NCO with spheroidal and close multi-layered concentric structures. Most of the structures are joined through their outside shells. The particle size is variable and their corresponding diameter distribution varies from 5-35 nm.

Fig. 3 shows a higher magnification image of a single NCO particle. The typical onion structure consisting of concentric carbon shells is clearly observed. The distance between the shells is approximately 0.378 nm which matched with the lattice parameter d002 (0.354 nm) of the bulk graphite (JCPDS 01-089-8487). This suggests that the deformation of the shells is induced during the mechanical treatment. On the other hand, the core of this nanoparticle has a semi-ordered arrangement. This arrangement is similar to that found outside of the particle.

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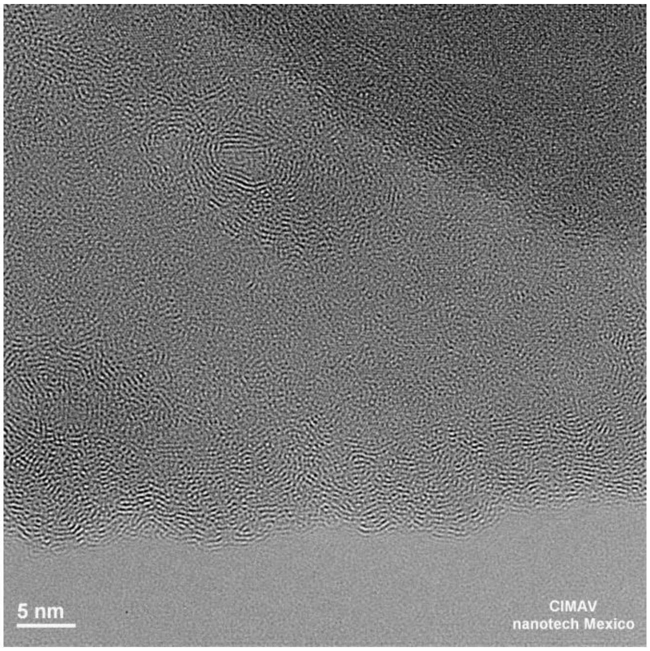

FIG.1. HRTEM micrograph from 1h milled sample after the leaching process, border section.

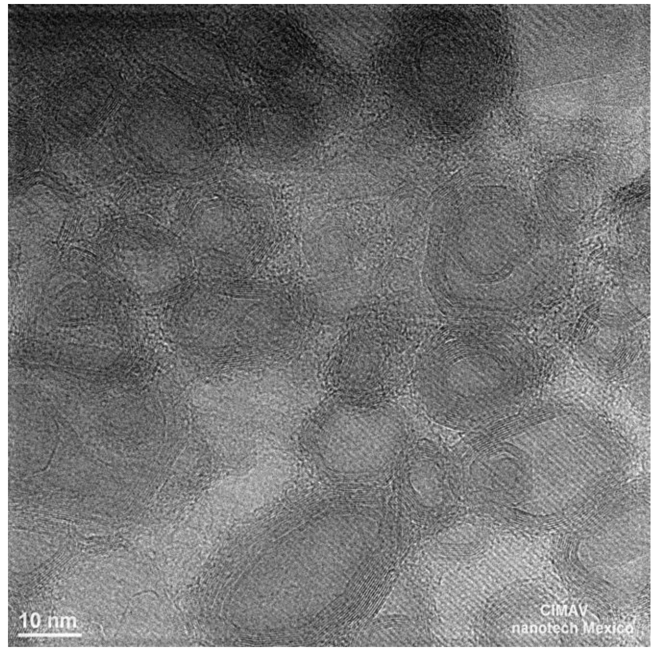

FIG.2. TEM micrograph showing a zone with a high density of NCO.

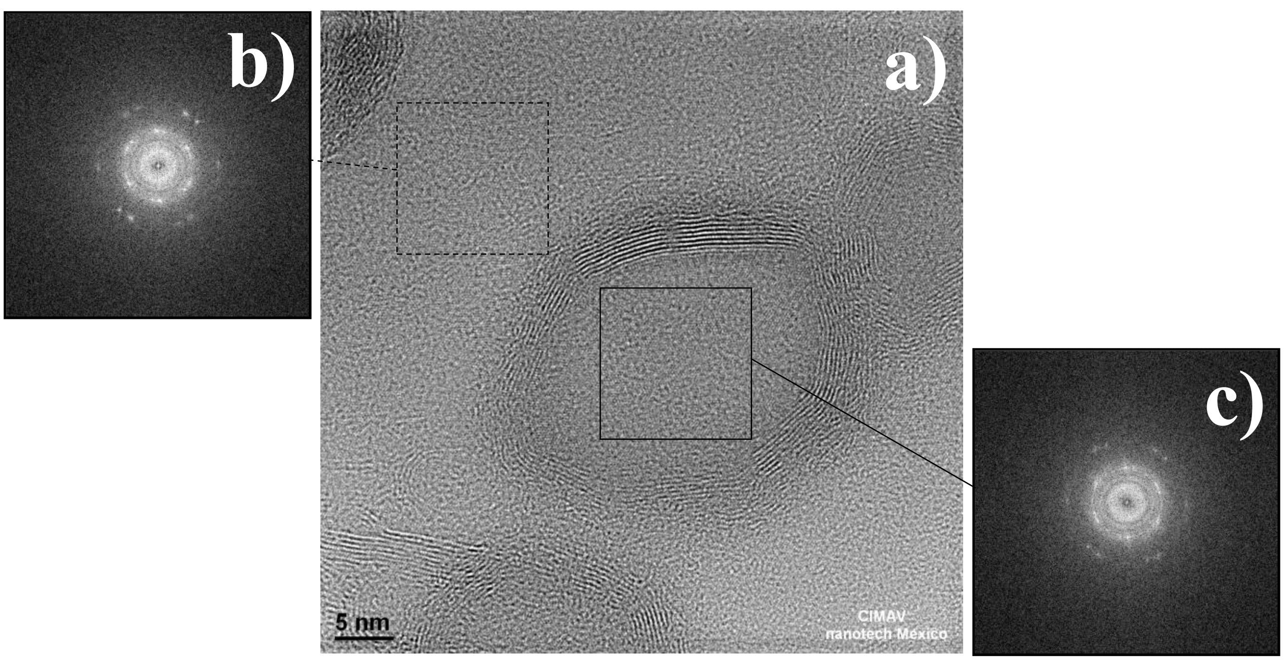

FIG. 3. a) High magnification image of a single NCO particle. Fast Fourier transform (FFT) from, b) outside the particle and c) the core.