Working paper

PUENTES CONSORTIUM Summer 2019 Visiting Scholar Program

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Collaborator at RICE UNIVERSITY: Dr. Pulickel Ajayan

Project: Carbon nanomaterials and carbon-based nanocomposites for energy storage

Activities related to the project

Carbon nanomaterials were synthesized at UDLAP. Materials synthesized in the APCVD (atmospheric pressure chemical vapor deposition) system were taken to Rice: nanospheres and graphite-like material. Composites of graphene oxide and magnetite were also taken to Rice, however due to the lack of time only the materials produced by APCVD could be studied. Figure 1 shows the morphology of the APCVD materials. Figure 1b, evidences the spherical nature of our nanostructures, while Fig. 1d demonstrates the layered nature of the graphite-like material. Although the morphology of the samples was known due to the examination by SEM available at UDLAP, the structure and their potential as materials for energy storage remained to be investigated. Taking advantage of the infrastructure at Rice and the collaboration with carbon nanomaterials expert Prof. Ajayan, both, the structure and the energy-storage application of the nanomaterials were studied.

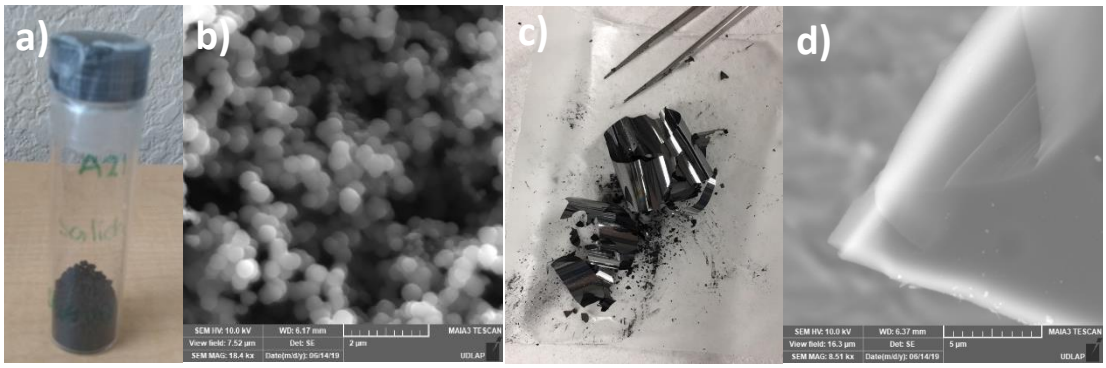

Figure 1, a) photograph of carbon nanospheres, b) SEM of the material in a), c) photograph of graphite-like material, d) SEM of the material in c)

At Rice, in Prof. Ajayan's research team with the Energy group, different activities were carried out in collaboration with the PhD student Abhijit Baburaj. The activities can be divided in two: characterization and energy-related experiments.

Characterization

X-ray diffraction of the two materials was carried out at the Shared Equipment Authority facilities, the resulting diffraction patterns are shown in figure 2. We can conclude that both materials are graphitic, although the shiny layered material (red line) presents indeed a more graphitic nature as can be appreciated by the sharpness of the (002) graphite plane at ~25°.

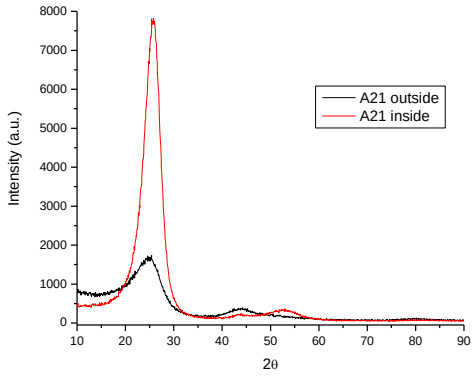

Figure 2. X-ray diffraction analysis of the APCVD produced materials, A21 outside (black line) corresponding to the nanospheres and A21 inside (red line) corresponding to the graphite-like material

Transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM) were also carried out on our samples in collaboration with Dr. Guanhui Gao.

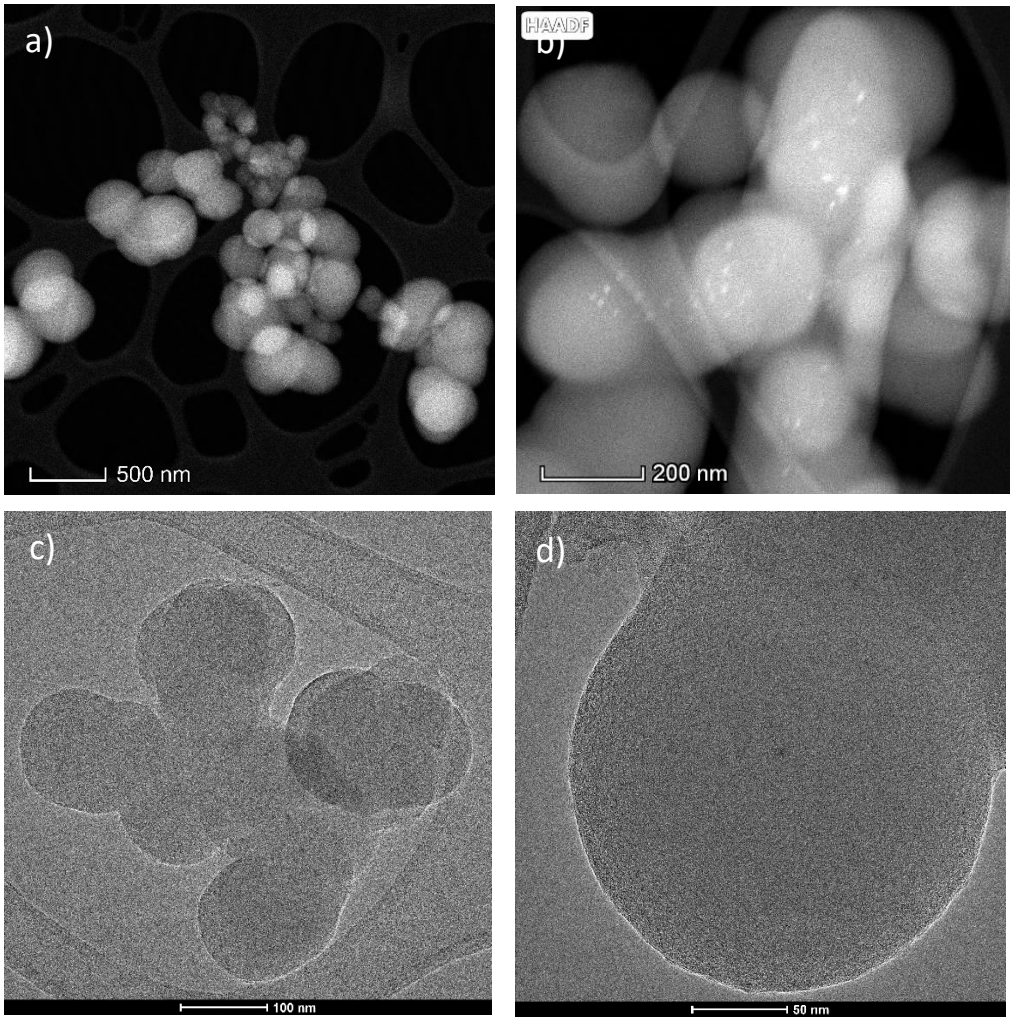

Figure 3 a and b STEM images of nanospheres, c and d TEM images of the nanospheres

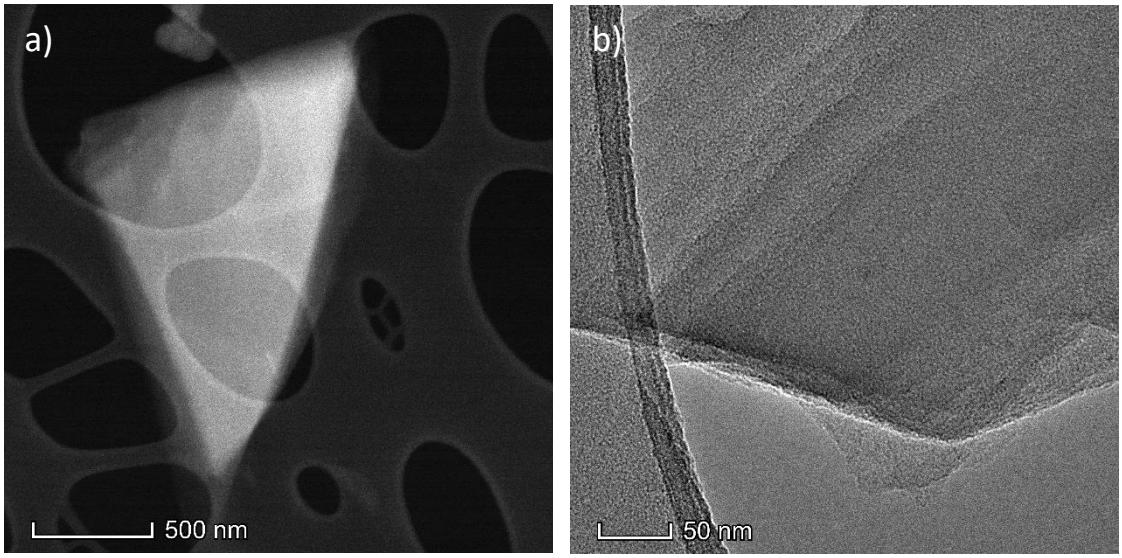

Figure 4 a) STEM and b) TEM of the graphite-like material

The characterization carried out allowed to confirm the graphitic nature of both materials, verified by XRD and TEM. The characterization carried out helped out to elucidate the structure of the materials, further work will be carried out to gather enough results for a publication.

Energy-related experiments

Slurries were prepared with both materials (nanospheres and graphite-like material), with these slurries, copper foils were coated in order to make electrodes for lithium cells (see Figure 5).

Figure 5. Copper foil piece coated with slurry made with carbon nanospheres, electrodes are cut out in circular shapes as can be seen in the right side piece

With these slurries stainless steel electrodes were also coated in order to test the materials as supercapacitors. Tests were run in the special equipment available at Energy Lab. However neither of the materials turned out to be promising for any use in energy applications.

Other activities

The director of NEWT Center (Nanosystems Engineering Research Center for Nanotechnology-Enabled Water Treatment), Prof. Pedro Alvarez was contacted and a talk was given to his research group with the objective of stablishing future collaborations. Dr. Rafael Verduzco, part of NEWT, was also contacted and common research interests were discussed.