Architecture Options for Carbon Nanotube Papers: Gradient Surface Area Paper and Other Varieties

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This presentation will describe how a selection of 12 different types of commercially-available carbon nanotubes may be utilized to create a variety of conductive, flexible, carbon nanotube papers designed for different energy-related applications. The emphasis will be on the structural and chemical options provided by the papermaking approach.

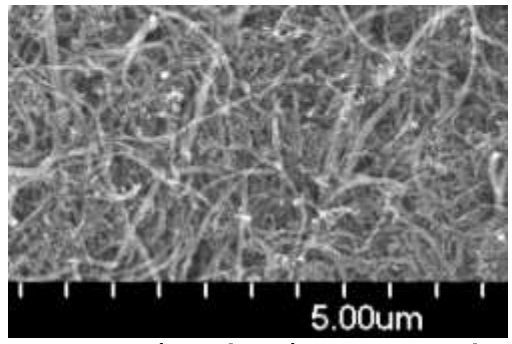
As carbon nanotubes become a commodity, they are available in bulk at a nominal cost. The process of fabricating them into conductive sheets via papermaking provides options for creating novel materials. For example, carbon nanotube papers may be made with entrained additives, or the papers may be coated, infused, catalyzed, or otherwise modified as desired. In this sense they are a platform to be built upon.

Nanotubes and nanofibers vary in morphology and span diameters from 2 to 500 nm. Combinations may be used to tailor sheets according to the target energy application. If the interest is in a high-rate electrode process, one might opt for a high surface area nanotube sheet that is relatively thin and densely packed. However, if some gas permeability is required (as in an air battery, or if the intent is to coat the fibrils with a CVD process), a different type of sheet is in order. We have found that nanotube sheets may be tailored for surface areas ranging from 16 to >350 m^2/g, with gas permeabilities that span two orders of magnitude, and they may be made with no binder content whatsoever. When these sheets are modified with active materials, it is possible to use them for both energy storage and current collection.

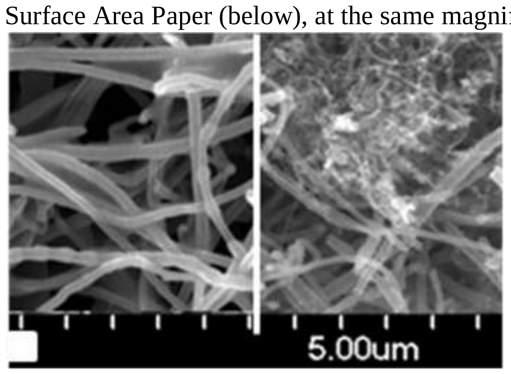
The formulation of a sheet with specific target properties is a holistic endeavor. When the intent is to achieve a specific density, surface area, and thickness, it is still important to be mindful of other considerations such as sheet strength, flexibility, conductivity, and surface wetting features. There are trade-offs involved, with different nanomaterials providing different attributes to the paper. The increasing availability of new starting materials will expand the preparative options with time.

A discussion of nanotube papers with a variety of morphologies, permeabilities, and entrained materials will be included. Electrochemical data will demonstrate how nanotube sheets tailored in different ways perform in specific energy storage/conversion applications. The advantages and limitations of nanotube papers will be reviewed, as well as our progress towards their continuous manufacture on custom-made equipment.

Electrode permeability can be an important property in energy-related mechanisms, and it is sometimes desirable to have a useful rate of gas permeation in combination with high surface area features. This can be done by creating a carbon nanotube paper with a gradient of surface area, i.e., where one face has a high surface area zone that is sufficiently thin that it does not markedly impede gas flow. The properties of such a gradient sheet will be compared to those of high- , low-, and medium surface area nanotube papers, with reference to how such a morphology is applicable to energy devices.



SEM image of a High Surface Area Nanotube Paper (above), contrasted with the front/back face of a Gradient Surface Area Paper (below), at the same magnification.



References

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