Renewable Energy Technology Gains By Interfacial Engineering With Carbon Nanomaterials

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ABSTRACT

Many forms of energy utilization, conversion and storage and generation are dominated by interfacial chemistry. Therein nanomaterials as an interfacial modifier can play a critical role in these processes. Examples presented include Li ion batteries, nanolubricants, nanofluids, polymer composites, gas sensors and catalysts.

Keywords: Energy conversion, conservation, efficiency

1 INTRODUCTION

Energy engineering encompasses energy processes such as conversion, generation, storage, efficiency, conservation and control. Creating a *new* paradigm, nanomaterials, when used as interfacial modifiers have the potential to significantly alter the energy landscape, given that these processes occur predominantly at interfaces.

2 EXPERIMENTAL

Experimental details will be presented at the presentation with regards to the synthesis and utilization of the nanomaterials.

3 RESULTS AND DISCUSSION

Results illustrate the theme and support the hypothesis of using nanomaterials as interfacial modifiers to advance gains in energy engineering. Selected examples *from the author's work* include catalysis, composite materials, energy storage, sensors, thermal management, and tribology.

Catalysis using Au nanoparticles (see Fig. 1) supported on oxides such as CeO_2, TiO_2 and Fe_2O_3 offer ambient temperature oxidation of CO, volatile organic compounds (VOCs) and potentially exhaust hydrocarbons.

Within polymer composites, interfacial modification of a metal foil using carbon nanotubes directly grown upon the foil is illustrated, in Fig. 2. The purpose of the foils is to serve as a gas impermeable barrier layer [1].

Substantial gains in Li ion battery cathode and anode materials have been realized using CNTs, coating processes. Treatment of the CNT surfaces is shown to increase the Li ion capacity beyond the theoretical limit of normal graphite [2], see Fig. 3.

Exploitation of nanoscale properties of metal oxides, aided by supported noble metal catalysts led to new NO_x and O_2 sensors, operable at ambient temperature [3], shown in Fig. 4.

Nanofluids with enhanced thermal conductivity for cooling applications are demonstrated using carbon nano-onions and carbon nanotubes, (see Fig. 5), increasing water thermal conductivity by ~ 20% [4].

Carbon nanolubricants can bridge the gap between fluid and solid materials [5]. As additives with liquids or greases, synergistic properties may be realized with superior performance relative to graphite, diamond like carbon (DLC) and even Teflon, as summarized in Fig. 6.

4 CONCLUSIONS

The key concept is that the nanomaterials serve as interfacial modifiers. Since most energy related processes are dominated by interfacial reactions, nanomaterials have the potential to dramatically affect energy conversion rates and magnitudes

5 ACKNOWLEDGEMENTS

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6 REFERENCES

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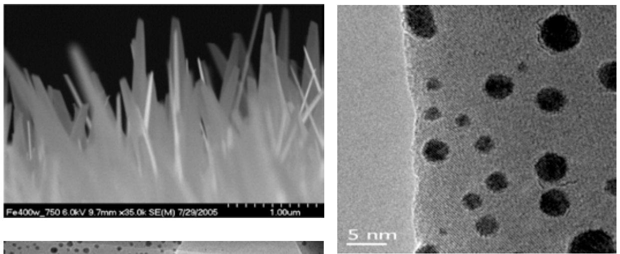


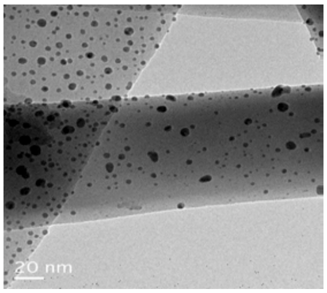
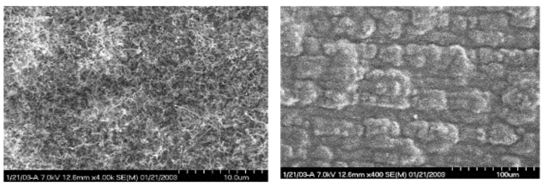


Figure 1. TEM Images Illustrating the Dispersion and Size Uniformity of Gold Nanoparticles upon Fe_2O_3 Nanoblades



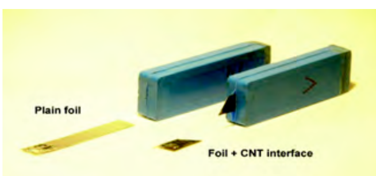
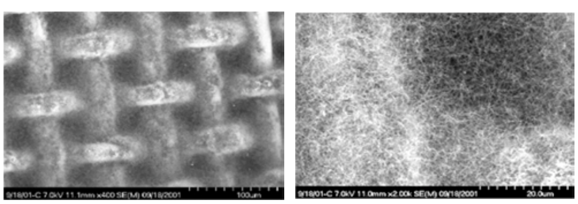


Figure 2: CNTs are used to create a three-dimensional interface Within a polymer composite. In the SEM images above, CNTs are synthesized upon the SS foil. Comparative tensile strength tests of "fuzzy" foil show that the interfacial bond between the SS foil and host polymer matrix exceeds the tensile strength of the 0.007-in. foil.



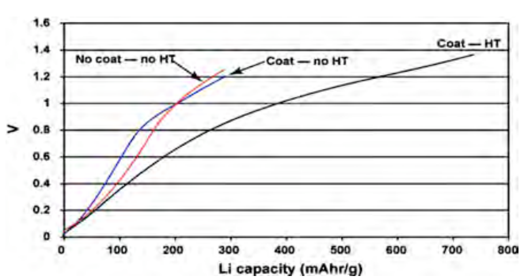
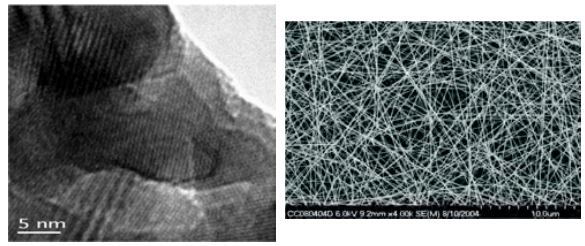


Figure 3. Scanning Electron Micrograph (SEM) Images of Carbon Nanotubes (CNTs) Synthesized Directly Upon Stainless Steel (SS) Mesh. The lower plot shows that the CNT surfaces increases the Li ion capacity beyond the theoretical limit of



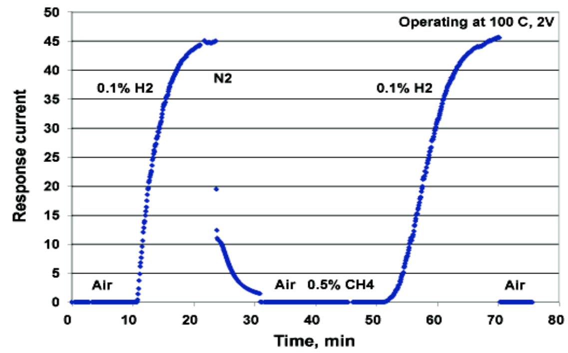


Figure 4. The above HRTEM (left) and SEM (right) images show polycrystalline nanofibers (1-d sensing elements) with demonstrated high sensitivity and selectivity to H2, at modest operating temperature with excellent cycling behavior.

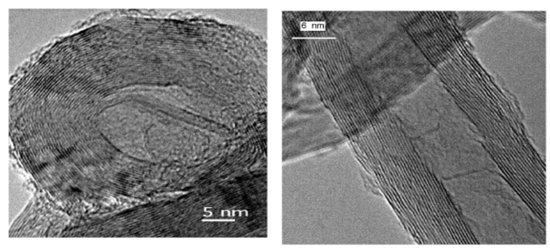
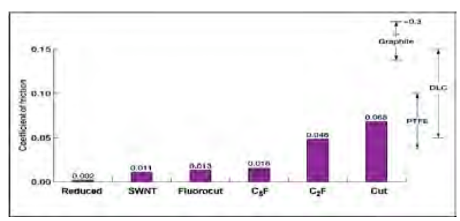


Figure 5. HRTEM images of nanocarbons that have been tested for use in nanofluids. Increases of ~ 20% in base fluid (water) thermal conductivity were measured for ~ 0.25 wt.% addition.



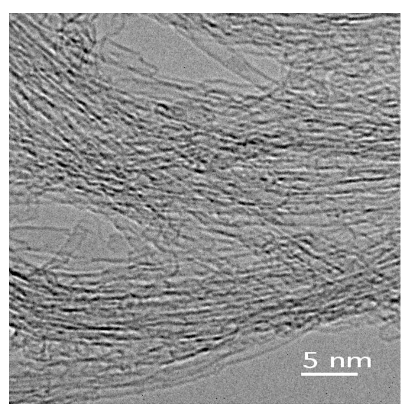


Figure 6. The bar-graph summarizes the coefficient of friction for SWNT nanomaterials with varied fluorine content. Relative to powdered graphite, DLC and even Teflon, the nanomaterials proved superior. A HRTEM image of these materials is also shown.