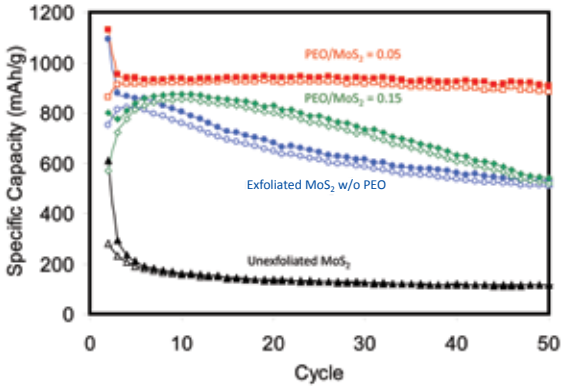
Energy Focus

Nanocomposites improve performance of electrode materials for Li-ion batteries

Researchers J. Xiao, J.P. Lemmon, and collaborators at Pacific Northwest National Laboratory picked up an old recipe and found out something new. The group synthesized nanocomposites of exfoliated MoS_2 and polyethylene oxide (PEO) using an existing technique. This time, however, they electrochemically tested the composite as a negative electrode in Li-ion batteries. In the August 24th issue of *Chemistry of Materials* (DOI:10.1021/cm101254j; p. 4522), the researchers report that the nanocomposite with 5 wt% PEO revealed very high specific capacity (reaching 1131 mAh/g) and longer cycle life than MoS_2 alone. Graphite, a conventional negative electrode battery material, has a theoretical capacity of 372 mAh/g.

MoS_2 is a promising alternative electrode material because it forms layers that are loosely coupled by weak van der Waals interactions, and the Li^+ ions can diffuse in the layers without inducing large volume change. The researchers found by scanning electron microscopy that exfoliated MoS_2 with weight percents of 0, 5, and 15 PEO exhibits a layered morphology with the morphology becoming more distinct with increasing polymer addition. The x-ray diffraction data and high-resolution transmission electron microscopy (HRTEM) images of the 5 wt% PEO material showed that the polymer does not significantly affect the *d*-spacing of exfoliated MoS_2 in the composite, but a weak reflection in the x-ray diffraction data of the 15 wt% PEO material suggests that as more PEO is added, a more ordered composite phase begins to form.

The researchers conclude that the very high capacity and cycling stability of 5 wt% PEO/MoS_2 is due to PEO maintaining a disorder in MoS_2 that allows Li^+ ions to diffuse into and out of the material repeatedly during cycling. PEO also coats the nanocomposite particles, which may enhance the ionic diffusion between electrolyte and particles.



Comparison of cycling stability for unexfoliated MoS_2 and exfoliated MoS_2 with different amounts of polyethylene oxide (PEO). All cells were cycled between 0.01 V and 3.0 V at 50 mA/g. Solid symbols, Li insertion; open symbols, Li extraction. Reproduced with permission from *Chem. Mater.* **22** (16) (2010) DOI:10.1021/cm101254j; p. 4522. © 2010 American Chemical Society.

The HRTEM micrographs showed that pristine, unexfoliated MoS_2 existed with the PEO/MoS_2 nanocomposite in the samples of prepared material. This finding "suggest[s] that it is possible to further improve the capacity of the composite by further optimizing the synthesis condition."

Ashley Predith

Energy Focus

Improved light emission in Ce^{3+} and Tb^{3+} co-doped $MgY_4Si_3O_{13}$ phosphors

White light-emitting diodes (LEDs) have recently been investigated to be employed in solid-state lighting device applications. A widely utilized approach to producing white LEDs is to combine blue LEDs with yellow-emitting phosphors (YAG: Ce^{3+}). Consequently, these LEDs produce cool white emissions and a low color rendering index due to their weak emissions in the green and red spectral range. An alternate approach for white lighting applications uses tricolor (red, green, and blue)-emitting phosphors excited by ultraviolet (UV) LEDs. Conventional phosphors are not suitable for white light-emitting systems employing UV-LEDs due to their weak absorption in the near-UV (NUV) region. Now, H.-Y. Chung, C.-H. Lu, and C.-H. Hsu of National Taiwan University have made strides toward overcoming these obstacles in solid-state lighting.

In the July issue of the *Journal of the American Ceramic Society* (DOI: 10.1111/j.1551-2916.2010.03626.x; p. 1838), the research team reported the synthesis and luminescence properties of $MgY_4Si_3O_{13}$-based phosphors, co-doped with varying concentrations of Ce^{3+} and Tb^{3+}. The $Mg(Y_{4-x-y}Ce_xTb_y)Si_3O_{13}$, ($0 \le x \le 0.2$, $0 \le y \le 1.0$) were prepared through a solid-state route, by grinding MgO, Y_2O_3, CeO_2, Tb_4O_7, and SiO_2 in a ball mill. Mixed powders were heated at 1400°C for 4 h in a tubular furnace under a reducing atmosphere (5 vol% H_2 and 95 vol% N_2).

The research team observed a marked enhancement in emission intensity from the co-doped samples, which was expected to be the effect of energy transfer between Ce^{3+} and Tb^{3+}. The excitation spectra appeared to result from the sensitizer Ce^{3+} and the line emission spectra originated from the activator Tb^{3+}. By comparing emissions of $Mg(Y_{3.6}Ce_{0.2}Tb_{0.2})Si_3O_{13}$ and $Mg(Y_{3.8}Tb_{0.2})Si_3O_{13}$, the emission intensity at 544 nm of the co-doped sample was 20 times that of the sample doped only with Tb^{3+}.

Similarly, the highest quantum efficiency of 49% observed in $Mg(Y_{3.4}Ce_{0.2}Tb_{0.4})Si_3O_{13}$ was increased from the 37% efficiency in $Mg(Y_{3.8}Ce_{0.2})Si_3O_{13}$, which was void of Tb^{3+}. However, for $y > 0.4$, a decrease in emission intensity is observed as the result of concentration quenching. With an increase in activator ions, the researchers observed increased interaction between

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