

Ionic Liquid-based Electrolytes with Dispersed Copper Nanoparticles for Dye-sensitized Solar Cells

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To enhance the electrical conductivity of the electrolyte in dye-sensitized solar cells (DSSCs), a very small amount of Cu@C core-shell (metallic copper (Cu) encapsulated in the carbon shell nanoparticles have been dispersed in room temperature ionic liquids (RTILs) (e.g., [bmim⁺][BF₄⁻] and [bmim⁺][PF₆⁻]). By the pulsed-field gradient spin-echo NMR method, the self-diffusion coefficients of cations and anions in the RTILs have been determined. It is found that the electrical conductivity of the RTIL with the dispersed (0.08%) Cu@C is increased by 3.5 times if compared with the plain RTIL (4.8→17.6 ms/cm). It is also worth to note that the self-diffusion coefficient of cations is increased by 4.3 times at the temperature of 300 K. It is clear that the Cu@C nanoparticles dispersed RTIL is a very effective electrolyte especially utilized in the DSSCs.

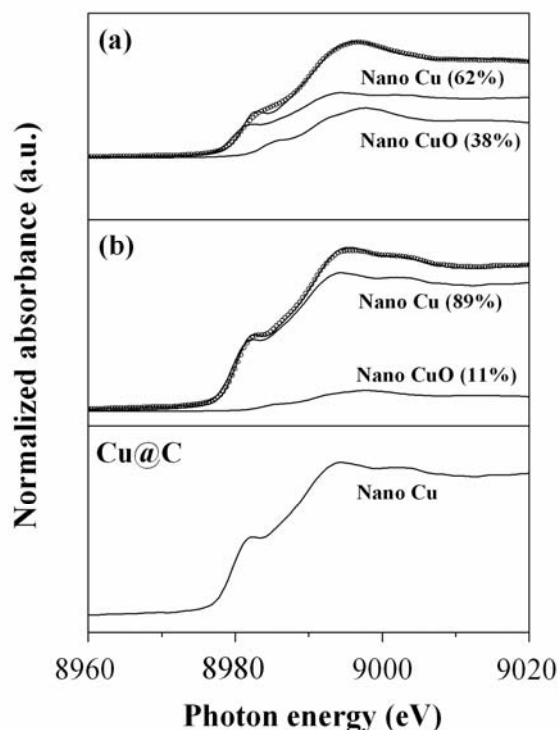
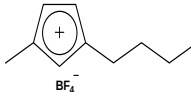
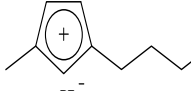


Fig. 1: The XANES spectra of copper in Cu@C (0.08%) dispersed in (a) [bmim⁺][BF₄⁻] and (b) [bmim⁺][PF₆⁻].

Table 1:

The self-diffusion coefficients ($10^{-11} \text{m}^2 \text{s}^{-1}$) of the Cu@C (0.08%) dispersed RTILs at 300 K

% Cu@C added		0	0.08
	Cyclic H ^a	1.34	5.70
	Alkyl H ^b	1.34	5.67
	F	1.15	7.56
	Cyclic H ^a	0.502	0.683
	Alkyl H ^b	0.510	0.671
	F	0.527	0.545

a: H atom on ring ; b: H atom on alkyl chain.

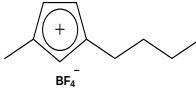
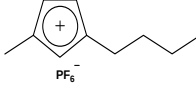
Table 2:

Structure parameters of copper in the Cu@C (0.08%) dispersed RTILs

RTIL	Shell	Bond distance (Å)	CN	Debye-Waller factor (σ^2)
[bmim ⁺][BF ₄ ⁻]	Cu-Cu	2.59	2.5	0.010
[bmim ⁺][PF ₆ ⁻]	Cu-Cu	2.52	4.7	0.007

Table 3:

Electrical conductivities (mS/cm) of the Cu@C dispersed RTILs at 300 K

% Cu@C	0	0.02	0.08
	4.77	5.94	17.6
	1.96	2.22	2.38