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Beyond solvents and electrolytes: Ionic liquids-based advanced functional materials

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Instead of being seen as alternative solvents and electrolytes for organic reactions, catalysis, separation, electrochemistry, and so on, ionic liquids (ILs) consisting of discrete cations and anions have recently emerged as versatile building blocks for advanced functional materials. A number of functional ILs and IL-containing composite materials have been realized by either chemical modification (covalent functionalization or ion-exchange metathesis) or physical

Abbreviations: 2D, two-dimensional; 3D, three-dimensional; [ACnIm][N(CN)$_2$], 1-allyl-3-alkylimidazolium dicyanamide; β, hyperpolarizability; BBI, benzobis(imidazolium); [BBIm][Br], 1,3-dibutylimidazolium bromide; [BH$_4$], tetrahydroborate; [BH$_2$(CN)$_2$], dicyanoborate; [BH3CN], cyanoborate; BiBz, 5,5-bibenz(imidazolium); [BMIm][FeCl$_4$], 1-butyl-3-methylimidazolium tetrachloroferrate; [C$_6$MIm], 1-hexyl-3-methylimidazolium; [C$_{12}$MIm][BF$_4$], 1-dodecyl-3-methylimidazolium tetrafluoroborate; [C$_n$OHMIm], 1-hydroxyalkyl-3-methylimidazolium; CNTs, carbon nanotubes; DDTC, diethyldithiacarbamate; DHBCs, double-hydrophilic block copolymers; DMF, N,N-dimethylformamide; DMSO, dimethyl sulfoxide; DN, donor number; DPA, dipropylamine; DTMN, dithiomaleonitrile; ECL, electrochemiluminescence; EDTA, ethylenediaminotetraacetic acid; EILs, energetic ionic liquids; [Eu(tta)4], tetrakis(2-thenoyltrifluoroacetonato)europate(III); F-BODIPY, 4,4-difluoro-4-bora-3a,4a-diazas-indacene; [FL], fluorescein; GO, graphene oxide; ID, ignition delay; I_E/I_M, the excimer-to-monomer fluorescence intensity ratio; ILCs, ionic liquid crystals; ILs, ionic liquids; LIG, liquid-in-glass; MO, methyl orange; MR, methyl red; MWCNTs, multi-walled carbon nanotubes; NPs, nanoparticles; NH3BH3, ammonia borane; [(N$_3$H$_6$)C][BH$_4$], guanidinium borohydride; [(N$_3$H$_8$C)C][BH$_4$], methylguanidinium borohydride; NLO, nonlinear optics; [NTf$_2$], bis(trifluoromethanesulfonyl)imide; [P$_{666,14}$], trihexyltetradecylphosphonium; PBnMA, poly(benzyl methacrylate); PIL, photonic IL; PMMA, poly(methyl methacrylate); ppb, parts-per-billion; QCM, quartz crystal microbalance; R&D, research and development; RH, relative humidity; RTILs, room temperature ionic liquids; SGCAs, soft glassy colloidal arrays; SILs, switchable ionic liquids; SWCNTs, single-walled carbon nanotubes; TEM, transmission electron microscopy; [TEMA][MeSO$_4$], tris(2-hydroxyethyl)methylammonium methylsulfate; TEMPO, 2,2,6,6-tetramethyl-1-piperidinyloxyl; THF, tetrahydrofuran; TNT, trinitrotoluene; UV, ultraviolet; WFNA, white fuming nitric acid; μ_{eff}, effective magnetic moment.

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integration of ILs and traditional materials. The unique structure and behavior of ILs as a platform not only provides additional opportunities to adjust the physicochemical properties of these ionic materials for task-specific applications, but also offers other attractive features such as intrinsic ionic conductivity and high thermal, chemical, and electrochemical stability. These soft materials combine the favorable features of ILs and the original chemistries of the functional groups or materials; some even possess unexpected functions resulting from synergetic interaction between these two components. Materialization of ILs is truly a novel, promising research direction for both IL chemistry and materials science. In this article, we review recent advances in IL-based functional materials, focusing on smart and sensitive materials, optical materials, energetic materials, and IL/carbon hybrid materials.

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