Investigations of Thermal Physical Properties and Utilizations of Room Temperature Ionic Liquids by Transient Grating and Thermal Lens Techniques

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Two different photothermal techniques (transient grating and thermal lens) have been used to study ionic liquids. The transient grating technique was used to determine thermal physical properties (thermal diffusivity and thermal conductivity) of room temperature ionic liquids (RTILs). The technique has relatively high precision with relative errors of about 1%. It also has relatively high accuracy: thermal conductivity values of RTILs determined by this method agree, within1% with values previously determined by other workers. More importantly, the technique is sensitive, non- destructive, fast, and requires only small amount of sample. In this study, we have used various RTILs with different anions and cations in order to determine the effect of anion and cation on the thermal physical properties of the RTILs. Results obtained seem to indicate that the anion exert strong influence not only on the sound velocity but also on the thermal diffusitivity and thermal conductivity of the RTILs: for RTILs with the same cation ($BMIm^+$), changing the anion from BF_4^- to either PF_6^- or Tf_2N^- leads to 7.9 and 21.5% decrease in the sound velocity, 12 and 30% decrease in the thermal diffusivity and 11 and 32 % decrease in the thermal conductivity (from (1564 +/- 8) ms^{-1}, (0.86 +/- 0.01)10^{-7} m^2s^{-1} and (0.161 +/- 0.002) $Wm^{-1}K^{-1}$ for $BMIm^+$ BF_4^- to (1441 +/- 4) ms^{-1}, (0.756 +/- 0.02)10^{-7} m^2s^{-1} and (0.143 +/- 0.004) $Wm^{-1}K^{-1}$ for $BMIm^+$ PF_6^- and to (1227 +/- 6) ms^{-1}, (0.60 +/- 0.01)10^{-7} m^2s^{-1} and (0.109 +/- 0.002) Wm-1 K-1 for $BMIm^+$ Tf_2N^-). Interestingly, the size of the cation does not seem to have observable effect on the sound velocity and the thermal diffusivity of the RTILs, namely the sound velocity and thermal diffusitivy of RTILs with the same anion (Tf_2N^-) and cation with alkyl group with different lengths are very similar. Specifically, the sound velocidy and thermal diffusivity for RTIL with C_2 alkyl group (i.e., $EMIm^+$ Tf_2N^-) are (1240 +/- 4) ms^{-1} and (0.601 +/-0.004)10^{-7} m^2s^{-1} which are similar to those of the RTIL with C_4 or $BMIm^+$ Tf_2N^- (1227 +/- 6) ms^{-1} and (0.60 +/- 0.01) 10-7 m^2s^{-1}), C5 or $PMIm^+$ Tf_2N^- (1227 +/- 2 ms^{-1} and (0.58 +/- 0.02)10^{-7} m^2s^{-1}), C_6 or $HMIm^+$ Tf_2N^- (1232 +/- 11 ms^{-1} and (0.606 +/- 009)10^{-7} m^2s^{-1}) and C_8 or $OMIm^+$ Tf_2N^- (1232 +/- 5 ms^{-1} and (0.61 +/- 0.01)10^{-7} m^2s^{-1}). Results from thermal lens measurements demonstrate that ionic liquids are superior solvent as, in addition to their high solubility power, they have relatively higher dn/dT value and lower thermal conductivity than water and other polar solvents. As a consequence, thermal lens measurements in ILs have relatively higher sensitivity than other solvents.