Ionic Liquids as Thermal Fluids

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The generation of solar electricity using large arrays of parabolic trough collectors is a practical and potentially inexpensive means of replacing the large-scale electrical generating plants that use gas, coal or nuclear energy as the heat source. Parabolic trough power plants need a fluid to transfer heat and store heat for short periods. A common thermal fluid that is commercially available and meets some of the requirements is a mixture of diphenyl ether and biphenyl, known as Therminol or Dowtherm. Ionic liquids may have thermal and chemical properties that qualify them as thermal fluids for solar energy or other heat transfer and storage applications.

There is no widely accepted set of specifications for thermal fluids, such as the ASTM standards for lubricating oils for example. The efficacy of ionic liquids as thermal fluids may be determined by comparing the properties of ionic liquids with an existing thermal fluid, or by comparing properties with the specific needs of a device or technology. In this paper we compare the properties of two of the most common ionic liquids with the requirements for thermal fluids in general and solar trough technology in particular.

The ionic liquids studied were 1-ethyl-3-methylimidazolium tetrafluoroborate, [emim][BF4], and 1-butyl-3-methylimidazolium tetrafluoroborate, [bmim][BF4]. These are just two examples of the hundreds of ionic liquids now described in the literature, and millions of possible ionic liquids. The examples chosen have the advantages of being stable towards air, are relatively well described in the literature, and are now commercially available. Not all thermal properties of these two materials are reported in the open literature, so we report some new thermal measurements here. It should be noted that not all relevant properties have been determined yet, but the matrix of properties determined so far indicate that ionic liquids are attractive candidates for heat transfer and storage.

The existing commercial thermal fluid used for comparison here is Therminol VP-1. Properties of this material that may be compared with the ionic liquids are: composition, freezing point, moisture content, viscosity, density, heat of fusion, boiling point (decomposition temperature), electric conductivity, use range of temperature, cost, appearance. We currently lack quantitative comparison data for flammability, thermal expansion, volume change at melting and freezing, surface tension, maximum film temperature, critical point quantities.

A set of thermal fluid target specifications for thermal trough technology was promulgated by the National Renewable Energy Laboratory. Ionic liquid properties that may be compared now with those targets are: latent heat storage density, sensible heat storage density, freezing point, thermal stability, vapor pressure, viscosity, cost. We lack quantitative data on materials compatibilities.

The effect of impurities on the properties of ionic liquids has been commented upon by several workers in the field, but is not widely appreciated. Impurities that have a greater or lesser effect on the thermal properties are water, chloride, and inorganic cations (usually Ag^+ or Na^+). In the properties reported here, we provide analyses of these contaminates and we show the effect of purposefully elevated amounts of them.