Ionic conductivity enhancement due to co-guest inclusion in the ionic clathrate hydrates

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In this study, we present the unique role of co-guest when it is additionally included in an ionic clathrate hydrate. First, the ionic conductivities of *x*THF•(*n*-Pr)$_4$NOH•32H$_2$O hydrates at various co-guest THF concentrations (*x* = 2, 1, 0.5, 0.25, 0.13, 0) were measured in a temperature range from −40 to −10 ℃ and at ambient pressure. The double 2THF•(*n*-Pr)$_4$NOH•32H$_2$O hydrate ($\sigma = 1.06\times10^{-3}$ S•cm^{-1}) exhibits ionic conductivity two orders of magnitude higher than that of THF-free (*n*-Pr)$_4$NOH•32H$_2$O hydrate ($\sigma = 6.01\times10^{-6}$ S•cm−1) at −30 ℃. This considerably different ionic conductivity behavior strongly implies that the inclusion of co-guest THF induces a structural transformation via host-water lattice distortion, providing such high conductivity values for the double (THF + (*n*-Pr)$_4$NOH) hydrate. We found a maximum conductivity of 0.0184 S•cm^{-1} at 1.49 THF mol% and −10 ℃. The present results provide strong evidence that THF serves as a promoter for greatly enhancing the ionic conductivity in ionic clathrate hydrates. The structure-II host lattices formed by THF inclusion can provide an effective pathway for moving the charge carriers.