Low energy recycling of ionic liquids via freeze crystallization during cellulose spinning

A new method for recycling ionic liquids (ILs) from a cellulose spinning process is suggested. The method involves the combination of freeze crystallization and evaporation of H\textsubscript{2}O from IL + H\textsubscript{2}O mixtures to recycle the ILs. Processes with EmimAc and EmimDep were used as references to develop this IL recycling method. EmimAc + 12.5 wt% H\textsubscript{2}O and EmimDep + 4 wt% H\textsubscript{2}O were selected for a quantitative mass and energy analysis of the cellulose spinning and IL recycling process (the maximal initial H\textsubscript{2}O levels in the ILs + H\textsubscript{2}O mixtures for cellulose dissolution were determined experimentally). The energy requirement for the freeze crystallization + evaporation method was compared to evaporation only for recycling of EmimAc and EmimDep. To produce 1 kg dry cellulose fiber, 45.4 MJ and 62.6 MJ are required for recycling EmimAc and EmimDep respectively by the freeze crystallization + evaporation recycling method. Using evaporation only, 66.9 MJ is required for EmimAc recycling and 99.9 MJ for EmimDep recycling per kg cellulose fiber produced. Thus, to fabricate 1 kg dry cellulose fiber using freeze crystallization + evaporation rather than evaporation, 21.5 MJ can be saved for EmimAc and 37.3 MJ for EmimDep recycling. We also show that compared to a classical Lyocell fiber production method using N-methylmorpholine-N-oxide (NMMO) as solvent, use of ILs is energy saving in itself. Hence, significantly less H\textsubscript{2}O is required in the cellulose spinning process with ILs than with NMMO, and in turn less H\textsubscript{2}O has to be evaporated for the solvent recycling.

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