Synthesis and Characterization of Poly(amic-acid)-Silver Janus Nanoparticles for CO_2 Separation Applications

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Nanoparticles (NPs) are of utmost interest in today's world because of their unique chemical-physical properties, which substantially differ from those of bulk materials. The tunable nature of NP properties enables the possibility of using them in a variety of applications, ranging from optics, nanomedicine, drug delivery, and molecular separations. In this regard, the possibility of designing functional nanoparticles and embedding them in polymer materials provides the opportunity to tune the transport properties in membranes and achieve highly selective molecular separations. However, because of their high surface energy, nanoparticles tend to aggregate, which can be prevented using appropriate stabilizing agents. In conjunction with the core NP, such agents may be used to evoke Janus transport properties through the simultaneous targeting of the diffusivity and solubility selectivity of dense polymer films.

In this study, Janus nanoparticles for CO_2 separation were rationally designed and synthesized by chelating silver nanoparticles with poly(amic-acid)s. This approach also eliminates any compatibility issue when these particles are embedded in polymer materials, while introducing ether functional groups, which greatly enhance CO_2 permeability and selectivity. The synthesized silver-PAA nanoparticles were thoroughly characterized via TEM/EDS analysis, showing that individual and un-aggregated particles with near spherical morphology (~5 nm) can be successful produced. The occurrence of the chelating reaction between silver and the PAA was confirmed via FT-IR. Finally, the effect of the PAA length and ether functional group concentration on the structure and properties of nanoparticles was systematically investigated. The silver-PAA Janus nanoparticles were then embedded into a commercial polymer, Pebax, to fabricate defect-free mixed matrix membranes for CO2 separation, whose structure and transport properties were systematically investigated.