Development of Temperature-Responsive Microgel Films for CO_2 Separation

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The chemical absorption of CO_2 using aqueous solutions of amines such as ethanol amine and sterically hindered amines has been considered to be the most scalable CO_2-capture processes from the high humidity exhaust gases of point sources such as fossil fuel power plants.[1] The amine solutions absorbs CO_2 at a low temperature (~40 °C) by an exothermic reaction and desorbed CO_2 upon heating (>140 °C).[2] Though these conventional methods exhibited high capacity for CO_2 capture, they have drawbacks, such as reactor corrosion and high-energy consumption—equivalent to 20–40 % of a typical power plant output because of the high regeneration temperature.[2-3] Furthermore, amines and their reaction products in the solution that are easily volatilized during the regeneration process need to be recovered in order to avoid air pollution.[4] Thus, the development of nonvolatile sorbents that desorb CO_2 at low temperatures (<100 °C) has been required.[3]

We have reported that the aqueous solutions of temperature-responsive microgel particles (GPs) consisting of *N*-isopropyl acrylamide (NIPAM) and *N*-[3-(dimethylamino)propyl]methacrylamide (DMAPM) reversibly absorbed CO_2 via volume phase transition (VPT) of the GPs. Poly(NIPAM) hydrogels underwent VPT from a swollen to a shrunken state at the volume phase transition temperature (VPTT).[5] The GPs were highly hydrated below the VPTT while above it, the water dissociated from the GPs, thereby allowing the shrinkage of the hydrogel structure. Most amines in the swollen GPs were capable of forming ion pairs with the absorbed bicarbonate ions below VPTT (30 °C). However, above VPTT (75 °C), the shrinkage of GPs lowered the pK_a value of these amines, resulting in efficient desorption of CO_2 (Figure 1).[5,6]

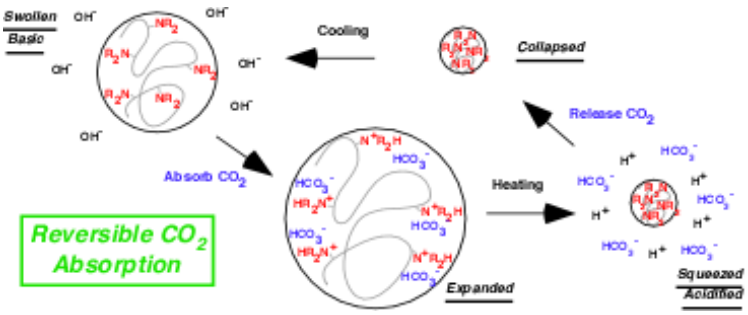

Figure 1. Proposed mechanism for reversible absorption of CO_2 by poly(NIPAm-*co*-DMAPM) GPs.

The capacity for CO_2 absorption per amine in the GPs in solution was either comparable or superior to the commercially available CO_2 absorbents consisting of ethanolamine.[5] However, the absorption capacity per weight of the solution was much smaller than that of the aqueous solution of ethanol amines because the concentration of GPs in the solution (~0.1 wt.%) was much lower than that of the amine solution (20–30 wt.%).[5] In order to improve the energy efficiency, we prepared hydrogel films consisting of the GPs.[6] The hydrogel films composed of temperature-responsive microgel particles (GPs) containing amine group work as CO_2 separation membranes as well as stimuli responsive CO_2 absorbent with a high capacity. [6-8]

References

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