Nano-Engineered Catalyst for the Utilization of CO2 in Dry Reforming to Produce Syngas

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The objective of this study was to develop a novel catalytic reactor containing nano-engineered catalyst for the utilization of CO_2 (captured from coal-fired power plants) in dry reforming of methane (DRM) ($CO_2 + CH_4 \rightarrow 2\ H_2 + 2\ CO$) to produce synthesis gas (syngas). The technology aims to reduce CO_2 emissions by developing beneficial uses for CO_2 from coal-fired power plants. It also offers an alternative to mitigate CO_2 emissions in areas where geologic storage may not be an optimal solution and/or utilization could significantly offset the costs of carbon capture and sequestration.

The nano-engineered Ni-based catalyst was prepared by atomic layer deposition (ALD). The Ni particles were as small as ~2-4 nm. The nano-engineered catalyst showed CH_4 conversion >90%, H_2/CO ratio in the range of 0.7-1.0, and CH_4 reforming rate as high as 2,200 L/h/gNi at 800 ºC and pressure of 15-25 psia. The Ni-based ALD catalyst also showed good stability in DRM reaction during a 300-hour continuous operation at temperatures that ranged from 700°C to 850°C. This is due to a strong bonding between the nanoparticles and substrates since the Ni nanoparticles were chemically bonded to the substrate during the ALD process. The high thermal stability maintains high dispersion of Ni nanoparticles, which can inhibit coke formation, because their step edges are small enough to limit carbon nucleation and growth.