Experimental investigation of CO_2 catalytic activity to hydrocarbon compounds over Ni nanocatalyst under conditions of CO_2 geological storage

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Carbon dioxide (CO_2) capture and storage (CCS) technology is a promising tool for reducing anthropogenic CO_2 emissions from fossil fuel combustion or other industrial sources to the atmosphere. The collected CO_2 can then be injected into geological formation reservoirs beneath low-permeability caprocks (shale or mudstone) at depths below 800 m. Within the geological environment, the injected CO_2 becomes in a supercritical state beyond its critical point (approximately 304K and 7.4 MPa) and migrates upward and eventually reaches at the bottom of caprock in the course of CO_2 injection due to the buoyancy effect of less-dense supercritical CO_2 ($scCO_2$). Also, considering natural structure of geological barriers such as caprocks, numerous pre-existing fractures are present, which may allow stored CO_2 to escape through them during CO_2 injection period, albeit extremely slowly, i.e. CO_2 leakage risk. Most notably, long-term stabilization of the injected CO_2 plays a critical role in the safe implementation of this technology, In fact, within geological reservoirs, majority of the stored CO_2 still remained as an immiscible phase of CO_2 in a supercritical state after 20 years of post-CO_2 injection. Owing to such challenges, we propose a novel CCS technology involving the direct conversion of CO_2 into hydrocarbon compounds without acting buoyancy force in a geological environment, by co-injecting a nanocatalyst with CO_2 into the CO_2 geological reservoir.

Our purpose of this study is to examine the catalytic activity for CO_2 conversion in the $scCO_2$ state using a nickel (Ni) nanocatalyst, which is widely used for a noble metal related to CO_2 capture and utilization and Fischer-Tropsch Synthesis technologies, on a laboratory scale.
Our results demonstrate that under CO_2 geological storage conditions, Ni nanocatalyst tested makes it possible to occur CO_2 hydrogenation to hydrocarbon compounds affording various wide variation of long-chain n-alkanes from liquid to solid phases, which could lead to reducing the risk of CO_2 leakage from storage reservoir through fractures in the caprocks.

Keywords: CO2, hydrogenation, Ni nanocatalyst, supercritical state, CCS technology

