Nonthermal plasma enabledelectrification of energy and materials conversion processes

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Power-to-gas conversion is highlighted where water electrolysis driven by renewable electricity produces hydrogen. Renewable hydrogen is directly used to drive fuel cell, or combined with catalytic conversion of CO_2 into CH_4 that is distributed through existing gas grid for widespread use. Based on the similar concept, we propose CH_4 conversion with CO_2 using nonthermal plasma enhanced catalytic reaction. This technology is known as dry methane reforming (DMR) and a mixture of CO and H_2 (syngas) is synthesized. Analogous to electrolysis of water splitting, renewable electricity is converted into chemical energy via nonthermal plasma assisted endothermic reaction. Syngas is converted preferably into carbon containing liquid fuels such as gasoline and methanol whose energy density is 10-100 times greater than that of secondary batteries. Transport and storage capability of renewable electricity is improved greatly and CO_2 utilization is realized simultaneously. Currently, the electrochemical reaction is dominantly studied for electrical-to-chemical energy conversion. Besides, nonthermal plasma provides additional energy and material conversion pathways, contributing to an extended carbon recycling network and fuel flexibility via the electrification of thermochemical reaction system. In this presentation, pulsed dry methane reforming (DMR; CH_4+ CO_2 = 2CO + $2H_2$) in Ni/Al_2O_3 catalysts and dielectric barrier discharge (DBD) hybrid reaction is presented with deep insight into reaction mechanisms.