Tailoring Oxidation of Al Particles Morphologically Controlled by Carbon Nanotubes

Hye Yun Jeong, and Young Hee Lee*

Center for Integrated Nanostructure Physics, Institute of Basic Science, Department of Energy Science, BK21 Physics Division, and Center for Nanotubes and Nanostructured Composites, Sungkyunkwan University (SKKU), Suwon 440-746, Korea

E-mail: leeyoung@skku.edu

Aluminum powder is used for energetic materials due to high energy density. Controlling oxidation rate, oxidation temperature, and reaction enthalpy are important parameters prior to practical use. Here, we engineered static and dynamic properties of oxidation of Al particles by mixing carbon nanotubes (CNTs) which have high thermal conductivity and large exothermic energy. Morphologies of Al/CNT mixture was engineered by a mechanical pulverization. Among various morphologies of Al/CNT mixture of i) CNTs adhered on the surface of Al particles, ii) CNTs partially embedded onto Al particles, forming an urchin type, and iii) CNTs fully embedded into aggregated Al particles, urchin type Al/CNT revealed the largest exothermic enthalpy at the lower oxidation temperature for both γ-Al₂O₃ and α-Al₂O₃ phases. This was attributed to the fast heat transfer into Al particles via partially embedded CNTs having high thermal conductivity. Large exothermic enthalpy of -121.7 kJ/g was obtained in oxidation of Al/CNT mixture (10 wt% CNT) compared to that (-10.2 kJ/g) of pure Al particles and the mass of alumina of Al/CNT mixture after 1000 °C oxidation was increased by four times compared to pure Al particles. The exothermic enthalpy showed strong dependence on the CNT content, increasing to -188 kJ/g at 20 wt% CNT. The engineering ability of thermal properties in Al particles with CNTs opens a new research area for diverse use of solid fuel Al.