【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Engineering)

Title of Project : Fabrication of fluidic ceramics with supercritical fluid technology toward dynamic thermal management

Tadasumi Adschiri
(Tohoku University, WPI-AIMR, Professor)

Research Project Number : 16H06367 Researcher Number : 60182995
Research Area : Engineering
Keyword : supercritical fluid, nano fluid, thermal management

【Purpose and Background of the Research】

Recently many methods have been developed for producing nanoparticles. However, the application based on the nanoparticles has not yet appeared. One of the main reason is the difficulty in controlling dispersibility of nanoparticles in organic solvents, or in polymers. Supercritical hydrothermal synthesis, which Adschiri had developed, enables synthesis of nanoparticles covered by organic molecules with high concentration. Since the surface is just like organic molecules, the nanoparticles shows high affinity to polymers. In addition, by tuning the particle size distribution properly, the hybrid nano-polymers (80 vol%) that shows fluidity could be fabricated ("fluidic ceramics"). This technology opened a door toward new hybrid materials. Many companies have started R&D for developing nano hybrid materials. However, the science for the fluidic ceramics had not yet been established.

The aim of this study is 1) to elucidate the mechanism of this fluidity of the hybrid materials, and establish the method to design the fluidic ceramics, and 2) to develop a high performance "thermal management materials".

【Research Methods】

1) Elucidation of the mechanism of organic modification on nanoparticles by using radiation analyses.
2) Estimation of phase behavior of nanoparticulate systems by combining computer science and chemical engineering thermodynamics. PVT of nanoparticles are measured, from which particle-particle interactions will be estimated. The interaction parameters thus evaluated will be used to predict the phase behavior of the nanoparticulate systesm.
3) Mathematic analysis (Persistent Homology) is introduced to describe the disordered structure of nanoparticles. This expression will be used to correlate the structure and fluidity (viscosity) of the fluidic cermaics.
4) A thermal management materials, namely fluidic ceramics with high heat conductivity, is designed, based on the above elucidated mechanisms. The nanoparticles modified with optimized molecules will be synthesized by the supercritical hydrothermal reactor.

【Expected Research Achievements and Scientific Significance】

1) A new science of rheology based on the relation between disordered structure and fluidity.
2) A designing method to design the organic modified nanoparticles, which shows high fluidity.
3) A method to describe disordered structure of nano particulate systems with the Persistent Homology.
4) Fabrication of a high performance "thermal management materials":
a) New materials that shows high fluidity and high thermal conductivity.
b) Transparent flexible nano-composit films with which the transmittance/reflection of light can be manipulated with the temperatures.

【Publications Relevant to the Project】

・ Byrappa K, T.Adschiri, "Hydrothermal technology for nanotechnology", Progress in Crystal Growth and Characterization of Materials, 53 117-166 (2007)
・ J.Zhang, S.Ohara, M.Umetsu, T.Naka, Y.Hatakeyama, T.Adschiri, "Colloidal ceria nanocrystals tailor-made crystal morphology in supercritical water" , Adv. Mater., 19, 203-206 (2007)

【Term of Project】 FY2016-2020

【Budget Allocation】 140,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.wpi-aimr.tohoku.ac.jp/ajiri_labo/english/index.html
ajiri@tagen.tohoku.ac.jp