Reply:

1. The enhancement mechanism of nanofluids is very complicated and challenging. Many researchers have been trying to give proper explanations. One can comprehend the reason that nanoparticles suspended in a base liquid increase the apparent thermal conductivity of nanofluids consisting of nanoparticles and base liquid from the two aspects: (1) the inclusion of suspended nanoparticles into a base liquid alters the composition of the original liquid as well as its morphology, so that one obtains a suspension mixture, which enhances energy transport inside the nanoparticle suspension. (2) The random Brownian motion of suspended nanoparticles and the induced micro-scaled disturbance of the liquid around these nanoparticles intensify the energy transport process inside the suspension. Generally, such enhancement increases with increase in the volume fraction of suspended nanoparticles and with decrease in the sizes of the nanoparticles. Choi and coworkers,[1,2] who have done a lot of pioneering work in the field of nanofluids, hold the similar opinions.
2. The suspended nanoparticles may be aggregated due to random motion, so that some nanoparticales clusters are formed. Such nanoparticle aggregation structures affect the thermal conductivity of nanofluids. A typical example is that the thermal conductivity of magnetic nanofluids in the presence of external magnetic field.[3] Besides other factors, in fact, the nanoparticle aggregation may be one of the main reasons that engender the discrepancy even dispute among the thermal conductivity data of nanofluids experimentally obtained by different groups. For nanofluids with the same volume fraction of suspended nanoparticles, the nanoparticle aggregation will degrade the thermal conductivity of the nanofluids. Unfortunately, the effect of nanoparticles aggregation on thermal conductivity of nanofluids was often overlooked, either intentionally or unintentionally. One can image the case that the nanoparticles suspended in a base liquid are aggregated into several clusters even a single cluster, the nanofluid will lose its feature and behaves like a liquid of carrying a few particles.
3. With respect to the question about the displacement of nanoparticles suspended in a base liquid, the explanation was made in a previous letter.[4] Here, the similar explanation is repeated as follows: using Langevin's equation, the mean square displacement of the nanoparticles can be found as

$$\langle x^2 \rangle = \frac{k_B T^B}{3\pi r_c \eta} t$$

Keeping in mind, the definition of thermal conductivity, we pay attention to the displacement of nanoparticles within unit time, that is, $t = 1$. In this case, the displacement per second is obtained as

$$l = \sqrt{\frac{k_B T^B}{3\pi r_c \eta}}$$

Thus, equation (10) in the previous work[5] is derived.

Literature Cited

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