Experimental Study on the CHF Enhancement of the Nanofluids containing Exfoliated Graphite Nanoplatelets(xGnP)

Eun ju Park [a], Sung dae Park [b], In cheol Bang [b], Hyung wook Park [a*]
[a]*School of Mechanical and Advanced Materials Engineering, UNIST*
[b]*Interdisciplinary School of Green Energy, UNIST*
100 Banyeon-ri, Eonyang-eup, Ulju-gon, Ulsan Metropolitan City 689-798, Republic of Korea
[*]*Corresponding author: hwpark@unist.ac.kr*

1. Introduction

The enhancement of the critical heat flux (CHF) contributes to increasing the safety margin of the thermal system. Nanofluids, stably dispersed nano-sized particles in base fluids, have been drawing attention as heat transfer fluids due to the CHF enhancement. The CHF enhancement can be explained by changing the morphology of the heater surface during the pool boiling. However, there are many factors to affect the CHF of the nanofluids, including the nanomaterials, the particle concentration and size, thermophysical properties of the nanofluids (surface tension, thermal conductivity and specific heat), and dispersibility[1-2].

Carbon based nanomaterials have drawn the tremendous interest from various areas due to their superior thermal and electrical properties. Among them, The exfoliated graphite nanoplatelets (xGnP) are the candidate to enhance the CHF of nanofluids due to the economical benefits compared to CNTs and grapheme. The xGnPs have layered structure with an average thickness of approximately 6-8nm. Since the manufacturing cost of xGnPs is much lower than that of CNTs and graphene, they can be the effective alternative.

In this study, nanofluids containing xGnP and xGnP oxide are prepared. We carried out the pool boiling experiments using xGnP and xGnP oxide nanofluids with different concentrations to examine the CHF enhancement.

2. Experimental setup and results

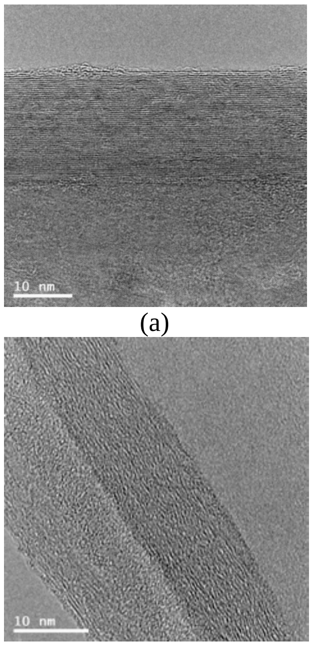
2.1 Experimental setup

The xGnP(M-5) powders were purchased from XG Sciences, Inc.. The xGnP oxide powders were prepared by the modified Hummers method. The two nanofluids were prepared by the sonication process. Fig. 1 shows the xGnP and xGnP oxide particles dispersed in the deionized water.

The pool boiling experiments were performed on the basis of Joule heating method. The CHF was calculated using the following equation:

$$q''_{CHF} = \frac{VI}{A} \quad (1)$$

Where I and V are the current and voltage, and A is the heat transfer area of the heater



(a)
(b)

Fig. 1. TEM images of (a) xGnP and (b) xGnP oxide particles

2.2 Results

The experimental results of the pool boiling experiments are shown in Fig. 2.

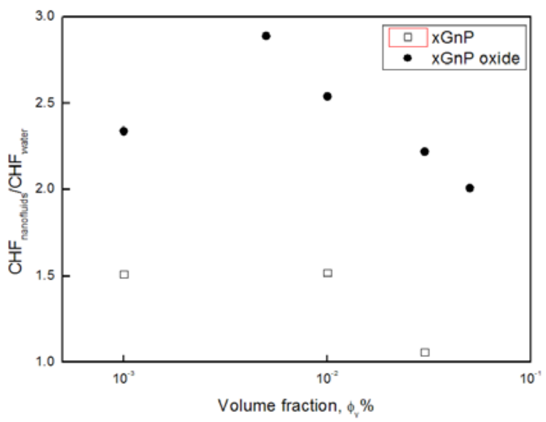
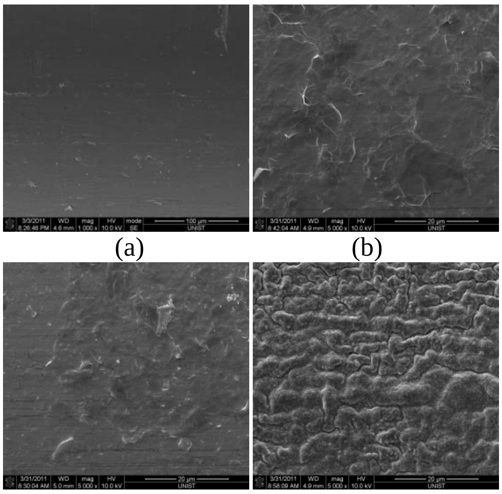


Fig. 2. The CHF enhancement according to different volume concentrations

The enhancement of the CHF was is 190% for the particle concentration of 0.005vol%. The morphology of the heater surface after pool boiling experiments according to different concentrations is shown in Fig. 3.



(a) (b) (c) (d)

Fig. 3. FE-SEM image of the heater surface after the pool boiling experiment of (a) water(x1000), (b) 0.005vol% xGnP oxide, (c) 0.01vol% xGnP oxide, and (d) 0.01vol% xGnP nanofluids(x5000)

In case of xGnP oxide nanofluids, the particles were deposited in the flat layer on the heater surface. As the volume concentrations increases, the thickness of the flat layer increases.

The contact angle on the heater surface after pool boiling experiment is shown in Fig. 4. According to other literatures, the higher contact angle corresponds to lower CHF. In this case, the CHF value of the xGnP oxide nanofluids is higher than that of xGnP nanofluids. However, their contact angle is smaller than that of xGnP oxide nanofluids.

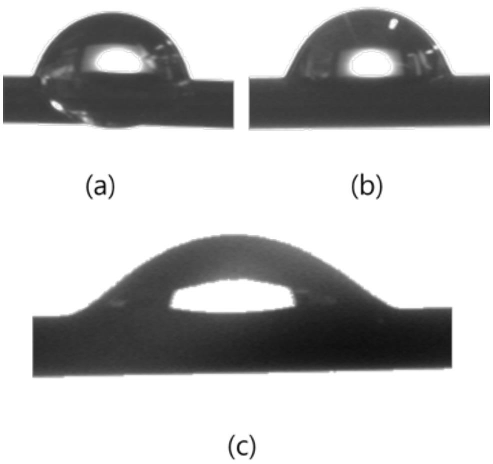


Fig. 4. Contact angle on heater surface after pool boiling experiment; (a) pure water, 70°, (b) 0.01vol% xGnP oxide nanofluids, 65°, and (c) 0.01vol% xGnP nanofluids, 35°

3. Conclusions

To investigate the CHF enhancement of xGnP/xGnP oxide nanofluids, pool boiling experiments were performed with various volume concentrations. Experimental results show that the CHF of the xGnP oxide nanofluids was enhanced to 190% compared to the pure water. This enhancement of the CHF of thexGnP/xGnP oxide comes from the deposition properties of the particles on the heater surface and thermal properties of nanomaterials.

REFERENCES

[1] I.C.Bang, S.Heung Chang, Boiling heat transfer performance and phenomena of Al2O3-water nano-fluids from a plain surface in a pool, International Journal of Heat and Mass Transfer, 48, 4105-4116, 2007

[2] Bao Truong, Lin-wen Hu, Jacopo Buongiorno, Tom McKrell, Modification of sandblasted plate heaters using nanofluids to enhance pool boiling critical heat flux, International Journal of Heat and Mass Transfer, 52, 85-94, 2010