Pool Boiling Enhancement with High Entropy Oxides (HEO)

Keval Suthar[1], **Md Moynul Hasan**[1], Saketh Merugu[1], Michal Marszewski[1], Anju Gupta[1]

[1]The University of Toledo

Abstract:

This study explores the potential of high entropy oxides (HEOs) as pool boiling additives in deionized (DI) water to enhance boiling heat transfer. Experiments were conducted using spinel [$(Al_{1/6}Co_{1/6}Cr_{1/6}Fe_{1/6}Mn_{1/6}Ni_{1/6})_3O_4$], perovskite [$La(Co_{0.2}Cr_{0.2}Fe_{0.2}Mn_{0.2}Ni_{0.2})O_3$, $Y(Co_{0.2}Cr_{0.2}Fe_{0.2}Mn_{0.2}Ni_{0.2})O_3$], and rock salt [$(Mg_{0.2}Co_{0.2}Ni_{0.2}Li_{0.2}Zn_{0.2})O$] structured HEOs. A significant enhancement in critical heat flux (CHF) and heat transfer coefficient (HTC) was observed. Specifically, 0.05 wt% $La(Co_{0.2}Cr_{0.2}Fe_{0.2}Mn_{0.2}Ni_{0.2})O_3$ yielded a 66.1% increase in CHF, while 0.05 wt% $Y(Co_{0.2}Cr_{0.2}Fe_{0.2}Mn_{0.2}Ni_{0.2})O_3$ improved CHF by 62.5% and HTC by 136.5% compared to the DI water baseline on plain copper surfaces. To investigate dispersion behavior and long-term colloidal stability, a 15-day ultrasonication-based dispersion test was conducted in DI water. The study identified key mechanisms for effective dispersion, including de-agglomeration, formation of hydroxyl functional groups, and electrostatic repulsion. These findings support the potential of HEOs as scalable additives for enhancing thermal fluids in pool boiling applications.

Experimental setup:

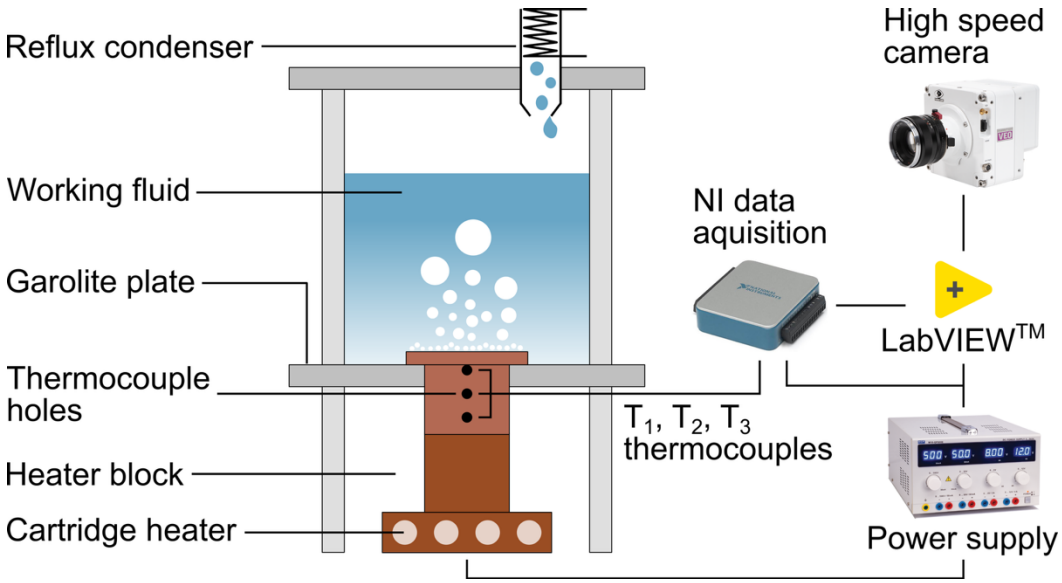

Fig 1: Schematic of the pool boiling setup along with thermocouple location for temperature measurements.

Results:

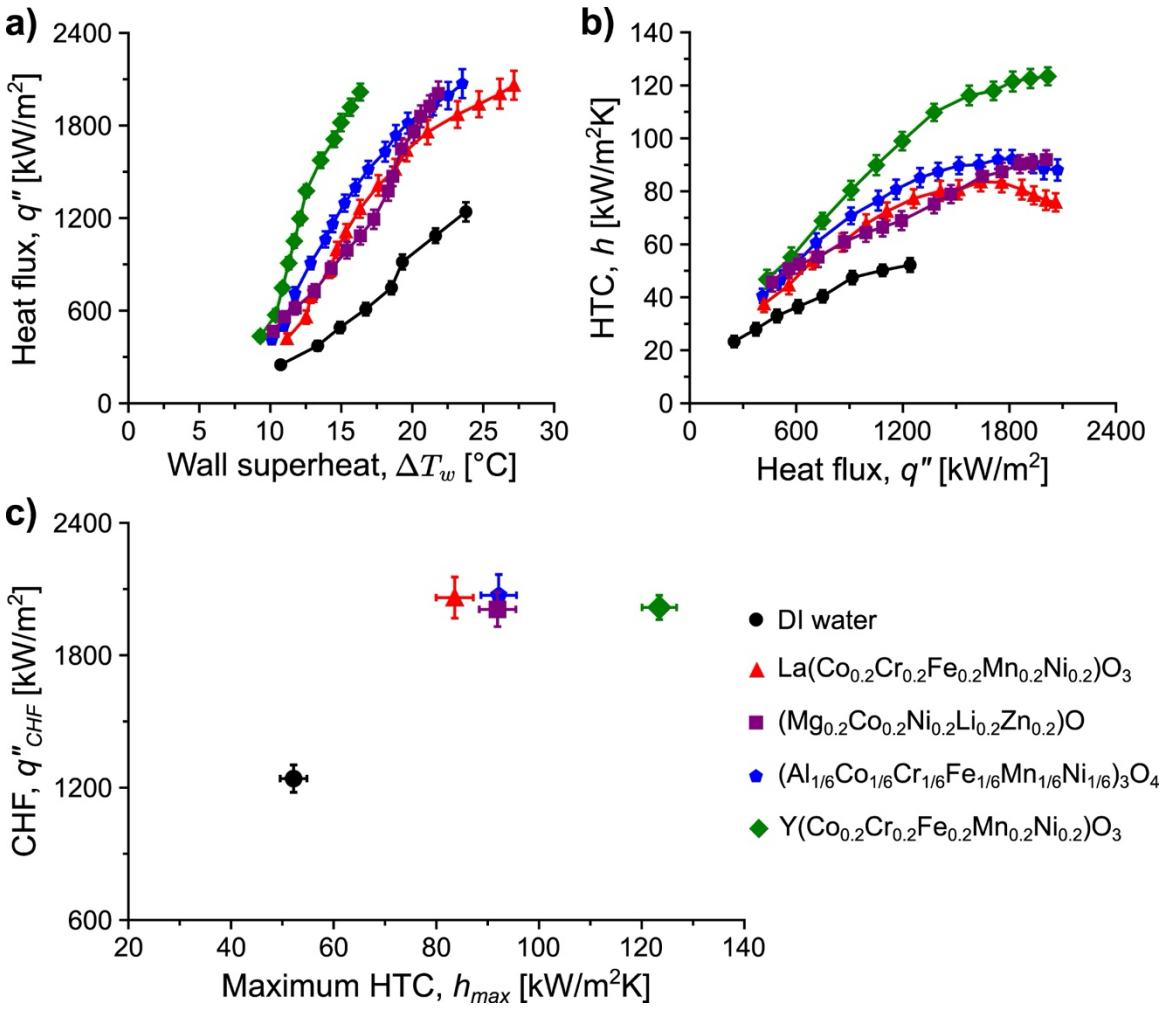

Fig 2: Boiling performance of HEO dispersions compared to DI water (a) heat flux vs wall super heat, (b) HTC vs heat flux, and (c) CHF vs maximum HTC (h_{max}).