No. 2113

Development of Innovative Salt Manufacturing Process Using Droplet Levitated on High Temperature Surface

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Summary

Salt is usually manufactured using an ion exchange membrane method where huge apparatuses such as boiler and turbine are utilized. To convert the huge plant to small one in the salt manufacturing process, a droplet reactor based on Leidenfrost effect was proposed in this study. When a droplet is dropped onto a solid surface that has been heated to a sufficiently high temperature above the boiling temperature of liquid, the droplet forms a vapor layer between the droplet and the solid surface and undergoes film boiling evaporation. This phenomenon is called Leidenfrost effect. When the Leidenfrost droplet is applied to the salt manufacturing process, the efficient evaporation of water from sodium chloride aqueous solution is expected due to the excellent mixing and mass transfer within the droplet. As preliminarily study, the performance of Leidenfrost droplet for salt manufacturing was investigated. Furthermore, it is known that a self-propelled Leidenfrost droplet on a rachet is observed. This motion can be regarded as a continuous droplet reactor. The possibility for continuous salt manufacturing using the self-propelled Leidenfrost droplet was also investigated.

The droplet produced with a syringe was freely fallen to on a duralumin plate heated below by a ceramic heater. Two types of plates were used: flat plate with a bowl-shaped cavity and plate with rachet-shaped top surface. The dynamic behavior on plates was observed by high-speed camera (HAS-D73, DITECT Corp.). The time for evaporation at each surface temperature of plate was measured. For the working fluid of droplet, distilled water, sodium chloride aqueous solution (NaCl), xanthan gum aqueous solution (XG), and sodium polyacrylate aqueous solution (SPA) were used.

The stable Leidenfrost state on the flat plate was observed at sufficiently high temperature in the case of water, XG, and SPA. On the contrary, NaCl droplet showed the unstable motion of droplet such as oscillation and bounce instead of stable Leidenfrost motion. On the rachet plate, the linearly stable motion of droplet was successfully implemented. In the future, combining results with two plates, the continuous salt manufacturing process with a small droplet will be developed.