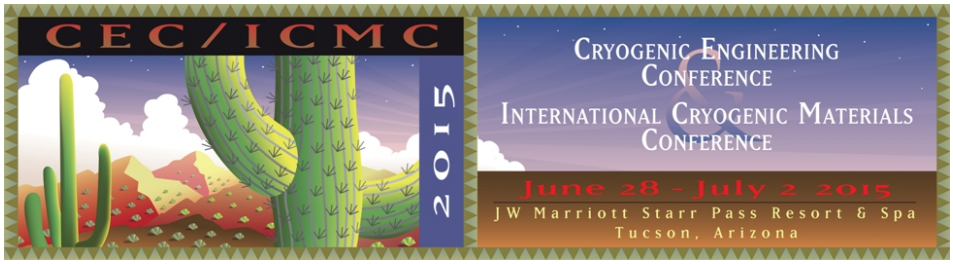

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Visual investigation of solid-liquid phase equilibria for non-flammable mixed refrigerant

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Mixed refrigerant (MR) which efficiently resolve the limitations of pure refrigerant for Joule-Thomson (J-T) cooling, draws a lot of attention from numerous researchers. Although MR can possess desirable characteristics for wide temperature range of cooling with partial evaporation and condensation, it has a significant operating challenge. Unlike hydrocarbon MRs, a non-flammable MR may have a fundamentally serious clogging problem at the J-T expansion part. This is due to the high freezing temperature of a constituent in the selected non-flammable MR. In this paper, the solid-liquid phase equilibria (i.e. freezing point) of the non-flammable MR which is composed of Argon, R14 (CF4), and R218 (C3F8), has been experimentally investigated by a visualized apparatus. Argon, R14 and R218 mixtures are selected to be efficiently capable of reaching 97 K in the MR J-T refrigerator system. Solid-liquid phase equilibria of mixtures have been tested with the molar compositions from 0 to 0.8 for each pure refrigerant. Each test result is simultaneously acquired by a camcorder for visual inspection and temperature measurement during a warming process. Experimental results show that the certain mole fraction of Argon, R14, and R218 mixture can achieve remarkably low freezing temperature even below 77 K. This unusual freezing point depression characteristic of the MR can be a useful information for designing a cryogenic MR J-T refrigerator to reach further down to 77 K.

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