Clathrate Superhydrides Under High Pressure Conditions: A Class of Extraordinarily Hot Conventional Superconductors

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Room-temperature superconductivity has been a century long-held dream of mankind and a focus of intensive research. Recent progress on findings of room-temperature superconductors among superhydrides stabilized at high pressure conditions is remarkable. Focus is placed on a class of clathrate superhydrides, the best ever-known family of superconductors, that exhibit extraordinarily high-T_c superconductivity (e.g., T_c = 260 K for LaH_{10} [1-4]).

The first-ever clathrate structure in superhydride is proposed in CaH_6 [5] by my group that shows a potential of high-T_c superconductivity at about 235 K. This clathrate structure accepts the emergence of unusual H cages, in which H atoms are weakly covalently bonded to one another, with Ca atoms occupying the centers of the cages. The high-T_c superconductivity is arising from the peculiar H clathrate structure.

We recently found a common rule of the formation of superconducting clathrate structures in rare earth (RE, e.g., Sc, Y, La, Ce, Pr., etc) superhydrides accompanying the occurrence of three different stoichiometries of REH_6, REH_9, and REH_{10}, some of which exhibit extraordinarily high-T_c superconductivity [1]. Subsequent experiments [3,4,6,7] indeed synthesized the as-predicted clathrate superhydrides YH_6, YH_9, and LaH_{10} with measured T_c values at 224, 243, and 260 K, respectively, setting up new T_c records among known superconductors. These discoveries open the door of achieving superconductors that could work at room temperature (300 K) in superhydrides.

In the talk, I will give an overview on the status of research progress on superconductive superhydrides, and then discuss the design principle for achieving room-temperature superconductor. Our prediction on a hot superconductor (T_c at ~400 K) in a clathrate superhydride Li_2MgH_{16} [8] together with future research direction will be discussed.

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