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$_2$MgH$_{16}$[8] together with future research direction will be discussed.


Keywords: High-Tc superconductivity, Clathrate structure, Superhydride

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