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Dual Reaction Model - A Review of Chemical Doping in MgB_2

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Studies on a large of number of dopants allows us to demonstrate a dual reaction model, which can explain the optimal doping effect achieved when the C substitution and MgB_2 formation take place at the same time at low temperatures. The C substitution is responsible for the enhancement in both H_{c2} and flux pinning. According to the dual reaction model we can evaluate and classify a broad range of dopants as the following sequence in terms of benefit to enhance J_c, $H_{irr,}$ and H_{c2}: the first group such as SiC and carbohydrates, which can have reaction and C substitution at the same temperature as MgB_2 formation; the second group such as nano C, CNT and B_4C which can have reaction and C substitution at temperature high than that for MgB_2 formation; the third group such as Si and a number of silicides which can have reaction at the same temperature as MgB_2 formation but without C substitution; and the forth group such as BN, MgO etc which have no reaction and substitution till very high temperature. The last group has little positive, if not negative, effect on J_c, $H_{irr,}$ and H_{c2} even at nano-scale. The understanding of dual reaction model has led to the discovery of the advantages of carbohydrate doping in MgB_2, resulting in a significant enhancement in J_c, H_{irr}, and H_{c2}. Carbohydrates decompose at temperatures near that of MgB_2 formation, thus producing highly reactive C, not dissimilar to the case of SiC doping. The model has a significant ramification to the fabrication of other carbon containing compounds and composites.