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Improvement of refrigerant capacity of $La_{0.7}Ca_{0.3}MnO_3$ material with a few percent Co doping

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ABSTRACT

The influence of first and second order magnetic phase transitions on the magnetocaloric effect (MCE) and refrigerant capacity or relative cooling power (RCP) of $La_{0.7}Ca_{0.3}MnO_3$ and $La_{0.7}Ca_{0.3}Mn_{0.95}Co_{0.05}O_3$ materials has been investigated. Large low-field-induced magnetic entropy changes are observed in $La_{0.7}Ca_{0.3}MnO_3$ and $La_{0.7}Ca_{0.3}Mn_{0.95}Co_{0.05}O_3$ materials. The $La_{0.7}Ca_{0.3}MnO_3$ material experiences a large entropy change with a first-order magnetic phase transition at the Curie temperature, T_C. On the other hand, $La_{0.7}Ca_{0.3}Mn_{0.95}Co_{0.05}O_3$ displays a smaller entropy change with a second order phase transition. While a first-order magnetic transition material induces a larger MCE (7.528 J/kg K at 5 T) at T_C, this is limited to a narrow temperature range, resulting in a relatively small RCP (218 J/kg), while the Co-doped second-order magnetic transition material induces a smaller MCE (7.14 J/kg K for 5 T), but it is spread over a broader temperature range, resulting in a larger RCP (308 J/kg). The maximum magnetoresistance (MR, defined as $\rho(0)/\rho(H)-1$) under a field of 5 T is about 206% and 333% for $La_{0.7}Ca_{0.3}MnO_3$ and $La_{0.7}Ca_{0.3}Mn_{0.95}Co_{0.05}O_3$, respectively. The refrigeration capacity (RCP) is enhanced in $La_{0.7}Ca_{0.3}Mn_{0.95}Co_{0.05}O_3$ (by about 41%) due to small changes from Co doping. The magnetocaloric features of these materials at lower magnetic fields (MCE=3.163 for $La_{0.7}Ca_{0.3}Mn_{0.95}Co_{0.05}O_3$ and 4.63 J/kg K for $La_{0.7}Ca_{0.3}MnO_3$ at 1 T), and the high RCP and MR can provide some ideas for exploring novel magnetic refrigerants that can operate with permanent magnets rather than superconducting ones as the magnetic field source.