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Synthesis of carbon-free Bi2223 superconductor of high phase purity

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Synthesis of Carbon-Free Bi2223 Superconductor of High Phase Purity

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ABSTRACT

$Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$ (Bi2223) is a high-T_c superconducting ceramic and this work is devoted to the synthesis of its high purity phase. In the past decade, although Tl- and Hg-based systems with higher T_c have been synthesised, their chemical toxicities limit their application potentials, hence Bi2223 remains one of the most promising materials, despite problems with attaining its pure phase, which is due to the uncertainty in its formation mechanism and the effect of residual carbon impurities. In this work, a four-step process has been developed, in which carbon-free intermediate compounds are fabricated by solid-state reaction. A series of thermoanalytical measurements had been performed on a large group of powder samples, with different combinations and proportion of the source chemicals Bi_2O_3, $SrCO_3$, $CaCO_3$ and CuO. Decomposition of Sr carbonate is activated in the mixture with precursor-A Bi_2CuO_4 from Bi_2O_3 and CuO. Two types of Bi_2CuO_4, with similar phase structure, are produced, and their respective effects on $SrCO_3$ have been identified. Then precursor-B, containing predominant Bi2201 and minor $Bi_2Sr_2O_5$, is formed. Precursor-C, a mixture of Ca_2CuO_3 and CuO, comes from the chemical reaction between $CaCO_3$ and CuO. All products and intermediates have successfully been identified with powder XRD.

For the exactly analysis of the kinetics of solid-state reaction, a new method has been developed. Its validity is experimentally confirmed.

Bi(Pb)2223 superconducting materials are synthesised using carbon-free precursors-B and -C as source chemicals. Based on TA and XRD data, an optimum procedure is formulated. In our precursor route, $Bi_2Sr_2O_5$ plays an important role in progressing toward highly pure Bi2223. The superconductivity and phase purity of processed materials are carried out. Although it is difficult to achieve pure Bi2223 in the nominal composition $Bi_{2.0}Sr_{2.0}Ca_{2.0}Cu_{3.0}O_{10+\delta}$, kinetics analysis suggests diffusion-controlled growth in $Bi_{1.84}Pb_{0.16}Sr_{1.84}Ca_{2.12}Cu_{3.04}O_{10+\delta}$ and $Bi_{2.0}Sr_{1.84}Ca_{2.12}Cu_{3.04}O_{10+\delta}$, which two compositions can be synthesised as carbon-free and phase-pure.

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