Proc. Indian Acad. Sci. (Chem. Sci.), Vol. 97, Nos 5&6, December 1986, pp. 631–633.

High T_c superconductivity in oxides derived from $La_{1.8}Sr_{0.2}CuO_4$†

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Abstract. Quasi two-dimensional copper oxides derived from $La_{1.8}Sr_{0.2}CuO_4$ by substitution of La, Sr or Cu show high T_c superconductivity.

Keywords. Superconductivity; two-dimensional copper oxides; $La_{1.8}Sr_{0.2}CuO_4$.

The discovery of high T_c superconductivity in La-Ba-Cu (~ 30 K) and La-Sr-Cu (~ 36 K) oxides of K_2NiF_4 structure (Cava *et al* 1987; Uchida *et al* 1987) has created widespread interest in this family of copper oxides. We have been interested in the crystal chemistry, magnetism and electrical properties of oxides of K_2NiF_4 structure for sometime (Ganguly and Rao 1984). In particular, we have reported that La_2CuO_4 exhibits a moderately low (1 ohm cm) temperature-independent resistivity (Ganguly and Rao 1973). Cu^{2+} ions in this oxide as well as other rare-earth copper oxides of the type Ln_2CuO_4 do not contribute to the magnetic susceptibility (Rao *et al* 1985). Partial substitution of La^{3+} by Sr^{2+} or Ba^{2+} in La_2CuO_4 gives rise to a mixed-valent system with a considerably lower resistivity having a value close to that found in various oxides at the borderline when the temperature coefficient of resistivity changes sign (Rao and Ganguly 1985). It appears that marginally metallic mixed-valent copper oxides of quasi two-dimensional character are good candidates for high temperature superconductivity (Rao and Ganguly 1987).

We have investigated several mixed-valent copper oxides of K_2NiF_4 structure for possible high-temperature superconductivity. We find that $La_{1.8}Sr_{0.2}CuO_4$ has a T_c of 36 K as reported by others; substitution of Sr by Ca in this oxide lowers the T_c. Thus, $La_{1.8}Sr_{0.1}Ca_{0.1}CuO_4$ exhibits the onset of superconductivity around 30 K (figures 1 and 2). Substitution of even a minute proportion of Cu by Ni appears to change T_c markedly. Thus, $La_{1.8}Sr_{0.2}Ni_{0.01}Cu_{0.99}O_4$ exhibits the onset of superconductivity around 24 K (figures 1 and 2). We are now studying the effect of substituting La by Pb and other ions, noting that both acidity and ionic size may be important in determining the superconducting transition temperature.

Substitution of La partially by Eu in $La_{1.8}Sr_{0.2}CuO_4$ has been examined. Thus $(La_{1.75}Eu_{0.25})_{1.8}Sr_{0.2}CuO_4$ exhibits a T_c of around 26 K (figure 1). It is interesting that the presence of Eu does not destroy superconductivity in this oxide system.

† Contribution No. 421 from the Solid State and Structural Chemistry Unit.
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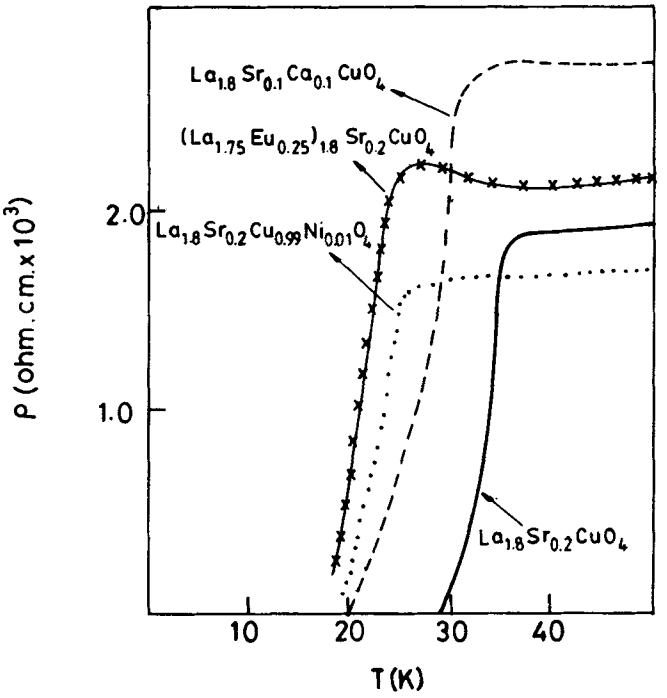

Figure 1. Resistivity data of copper oxides of K_2NiF_4 structure exhibiting superconducting transitions.

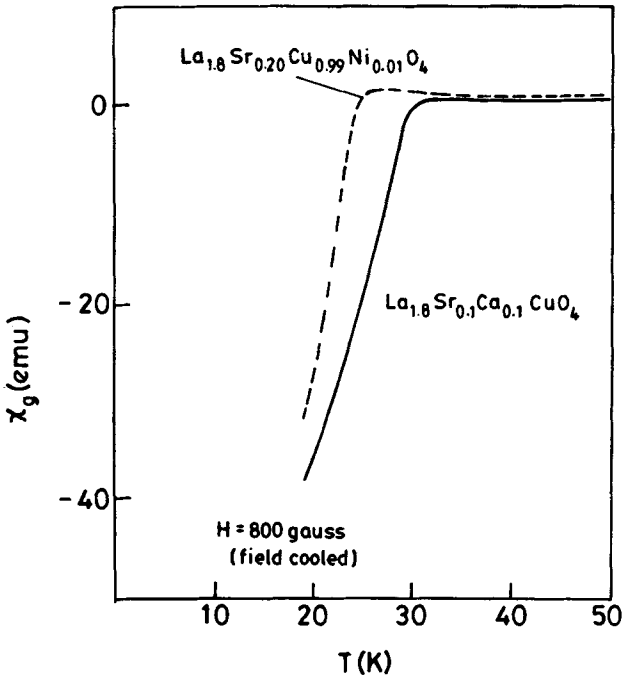

Figure 2. DC magnetic susceptibility ($\times 10^6$) data of copper oxides of K_2NiF_4 structure exhibiting superconducting transitions.

We are investigating systems of the type $(La_{1-x}Ln_x)_{2-y}B_yCuO_4$ with Ln = Pr or Nd and B = Sr or Ba. These systems are interesting in that only at a particular concentration of Pr or Nd, the oxide system is stable in the K_2NiF_4 structure (Singh *et al* 1982). We are now examining the relation between the lattice instability in these oxides and the superconducting transition temperature.

Acknowledgement

The authors thank the University Grants Commission and the Department of Science & Technology, Government of India, for support of this research.

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