A Search For Novel Non-Centrosymmetric Superconductors

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Abstract

Solid State and Lithium Intercalation synthesis techniques can both be used to dope materials, the former being much more common. We use these techniques to perform doping studies of and search for novel non-centrosymmetric superconductors in two families of materials: $REBaCuBO_5$ and Li_xTaOCl_2. We succeed in conducting the first doping study of $REBaCuBO_5$, creating a new Lithium intercalated material, and discovering a weakly superconducting signal caused by some material likely in the phase space of Li_xTaOCl_2.

Motivation & Background

$REBaCuBO_5$ (Fig. 1a) is naturally non-centrosymmetric – it has a lack of inversion symmetry around a central point. It also has a CuO square net layer, which is exactly what is believed to facilitate superconductivity (SC) in the Cuprate superconductors. However, the bond lengths in the CuO square net are uneven in this material, inhibiting SC. Proper doping conditions need to be found to resolve this issue.

Lithium Intercalation can be utilized as a technique to dope materials which cannot be doped using traditional solid state methods. TaOCl2 is one such material, a naturally dimerized and insulating material. Upon Li intercalation, the material suppresses a potential Charge Density Wave (CDW) and becomes undimerized (Fig. 1b), metallic, and hopefully a high TC Superconductor under the right doping conditions.

Methodology

Solid State methods were used to carry out the doping study of $REBaCuBO_5$. For all results shown here, precursors were mixed using a mortar and pestle for at least 10 minutes and then heated in a box furnace at 1070 °C for 12 hours with a 100 °C per hours ramp up and down. A regrind and reheat was performed at 450 °C for 24 hours afterwards to reoxidize the material, decreasing impurities and increasing chemical pressure.

The Lithium Intercalation process was setup by stirring 100 mL of THF, 2 g of Benzophenone, and 100 mg of Li metal in a flask until the solution turned dark blue. This indicates that the Li is in a radical state and ready to intercalate into the material. We then added the material to the solution for varying amounts of time and under varying heating conditions.

Magnetism measurements were performed using a SQUID Magnetometer and XRD measurements were done at Room Temp.

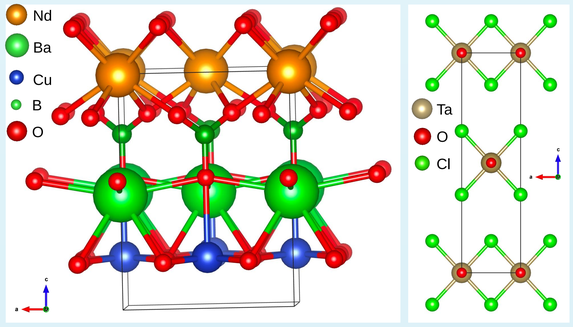

Fig. 1: (a) Structure of $REBaCuBO_5$. **(b)** Structure of Li_xTaOCl_2.

Results

XRD and MPMS measurements for a doping study of the Ba site in $REBaCuBO_5$ are shown in Figures 2a and 2b respectively. While the site is successfully doped, magnetism measurements only show significant change for RE = Nd and no SC was seen.

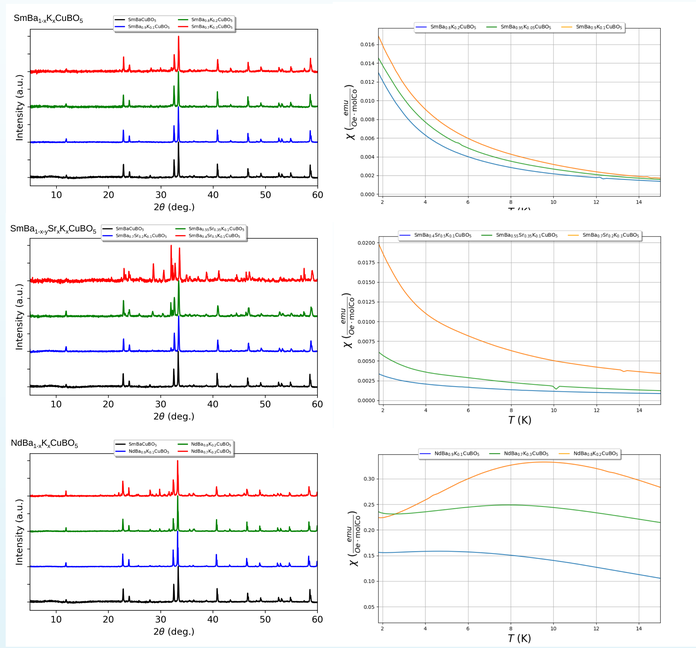

Fig. 2: (a) XRD and **(b)** MPMS Data for $REBaCuBO_5$ Doping Study

Using Li Intercalation we successfully interstitially doped Li_xTaOCl_2, as shown from the XRD data in Figure 3a. The appearance of a superstructure peak indicates a doubling in periodicity of the (002) plane. A very weak and reproducible superconducting signal with T_c of ~3.5 °K and ~6 °K for powder samples and only ~6 °K for crystal samples was found in this material as shown in Figure 3b. This likely indicates that the superconducting phase is some binary or trinary in the phase space of Li_xTaOCl_2 not seen in the XRD data. Further research is needed to isolate this phase.

Conclusion

We have shown that it is possible to dope $REBaCuBO_5$ with solid state methods and in doing so to change its magnetic properties, although SC was not found.

We also created a new Li Intercalated material, Li_xTaOCl_2. A weak superconducting signal was found but further research is needed to isolate the SC phase.

Acknowledgements

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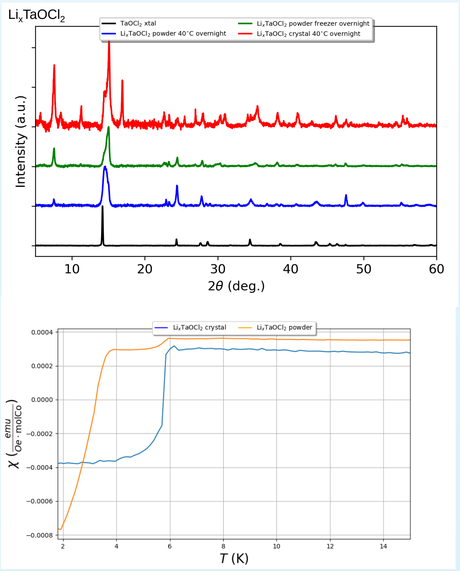

Fig. 3: (a) XRD Data of Li_xTaOCl_2 synthesized under different conditions. **(b)** Susceptibility measurements of Li_xTaOCl_2. A weak and reproducible SC signal can be seen