

This article was downloaded by: [University of Haifa Library]

On: 11 August 2012, At: 10:55

Publisher: Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/gmcl20>

Superconductivity of [Pd(dmit) 2] Salts under Pressure Studied by an RF Technique

Seiko Ohira ^a , Masafumi Tamura ^a & Reizo Kato ^a

^a Condensed Molecular Materials Laboratory, RIKEN (The Institute of Physical and Chemical Research), 2-1 Hirosawa, Wako, Saitama, 351-0198, Japan

Version of record first published: 18 Oct 2010

To cite this article: Seiko Ohira, Masafumi Tamura & Reizo Kato (2003): Superconductivity of [Pd(dmit) 2] Salts under Pressure Studied by an RF Technique, *Molecular Crystals and Liquid Crystals*, 379:1, 41-46

To link to this article: <http://dx.doi.org/10.1080/713738683>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.



Superconductivity of [Pd(dmit)₂] Salts under Pressure Studied by an RF Technique

SEIKO OHIRA, MASAFUMI TAMURA and REIZO KATO

*Condensed Molecular Materials Laboratory, RIKEN (The Institute
of Physical and Chemical Research), 2-1 Hirosawa, Wako,
Saitama 351-0198, Japan*

An instrument for detection of a shielding effect of RF magnetic fields (2 - 8 MHz) has been developed to investigate the characteristics of the superconductivity (SC) of some [Pd(dmit)₂] salts. The main part of the system consists of two *LC* oscillators, which can operate at low temperatures. The shielding signal due to a superconducting transition of the sample in the coil is detected as an increase of the frequency of the RF output. The coils are set within a clamp-type pressure cell.

SC in a few [Pd(dmit)₂] salts was investigated by using this system. An increase in the frequency was observed below 4 K under pressure. This may indicate the existence of the superconducting transition of the [Pd(dmit)₂] salts. However, the shielding signal was about 10⁻² times as small as that observed in an ordinary organic superconductor such as κ-(BEDT-TTF)₂Cu[N(CN)₂Br]. This peculiarity of the SC in the [Pd(dmit)₂] salts is reported.

Keywords: [Pd(dmit)₂] salts; superconductor; RF shielding

INTRODUCTION

Molecular conductors based on acceptor molecules, metal-dithiolene complexes $M(\text{dmit})_2$ ($M = \text{Ni, Pd, Pt}$) ($\text{dmit} = 1,3\text{-dithiole-2-thione-4,5-dithiolate}$) are of interest in their various structural and physical properties. In particular, some of $[\text{Pd}(\text{dmit})_2]$ salts are known to show peculiar pressure and temperature dependence of the electric conductivity. For instance, $(\text{CH}_3)_4\text{Sb}[\text{Pd}(\text{dmit})_2]_2$ and $(\text{C}_2\text{H}_5)_2(\text{CH}_3)_2\text{P}[\text{Pd}(\text{dmit})_2]_2$ (abbreviated as $\text{Me}_4\text{Sb}[\text{Pd}(\text{dmit})_2]_2$ and $\text{Et}_2\text{Me}_2\text{P}[\text{Pd}(\text{dmit})_2]_2$, respectively) behave as an insulator in the low pressure region. As pressure increases, the systems exhibit metallic behavior and then superconducting transition at low temperature. In addition, a non-metallic phase appears again in higher pressure region^[1,2].

In order to probe the characteristics of the SC of these materials, we have developed an instrument which can detect a shielding effect of RF magnetic fields (2 - 8 MHz). We found that the SC in the measured $[\text{Pd}(\text{dmit})_2]$ salts is different from that in an ordinary organic superconductor. In the present paper, the peculiarity of the SC in $[\text{Pd}(\text{dmit})_2]$ salts is reported.

EXPERIMENTAL

A diagram of the measurement system is shown in Figure 1. The main part of the system consists of two LC oscillators, which can operate at low temperatures. The two coils in the circuits are set within a clamp-type pressure cell. 2 - 3 mg of polycrystalline sample is mounted in the one coil (2.5mm ϕ , 30 turns \times 3 layers). The samples put in the coil are put between glass wool containing pressure medium and held

by Teflon stoppers to be kept in the coil. A piece of tin wire ($1.0\text{mm}\phi$) was put in the other coil ($2\text{mm}\phi$, $22\text{ turns} \times 3\text{ layers}$) as a manometer.

The RF signal output from the oscillators ($2 - 8\text{ MHz}$, depending upon the L and C values) is led to a frequency counter. The shielding signal due to a superconducting transition of the sample in the coil is detected as an increase of the frequency of the RF output of the oscillator.

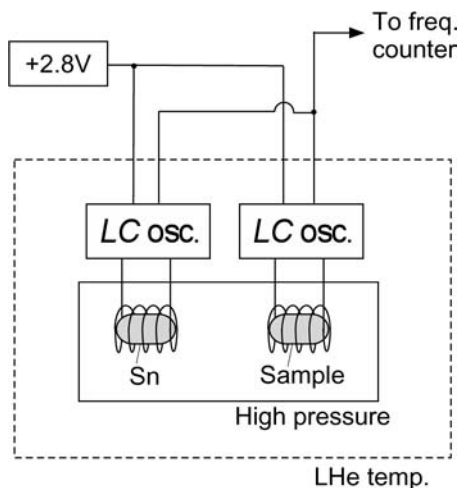


FIGURE 1 Diagram of the measurement system.

In such a system, heating up of the coil is often taken notice. We succeeded to minimize the alternating current in the coil by using CMOS devices which can operate with a low voltage power supply (2.8 V). The oscillator circuit itself is so small that it is easily installed in a LHe dewar together with the clamp cell.

Using this system, the SC in $\text{Me}_4\text{Sb}[\text{Pd}(\text{dmit})_2]_2$, $\text{Et}_2\text{Me}_2\text{P}[\text{Pd}(\text{dmit})_2]_2$ and $\text{Et}_2\text{Me}_2\text{N}[\text{Pd}(\text{dmit})_2]_2$ were studied down to 2 K under pressure. The temperature of the pressure cell was monitored by a thermometer set in a copper block contacted onto the cell.

RESULTS AND DISCUSSION

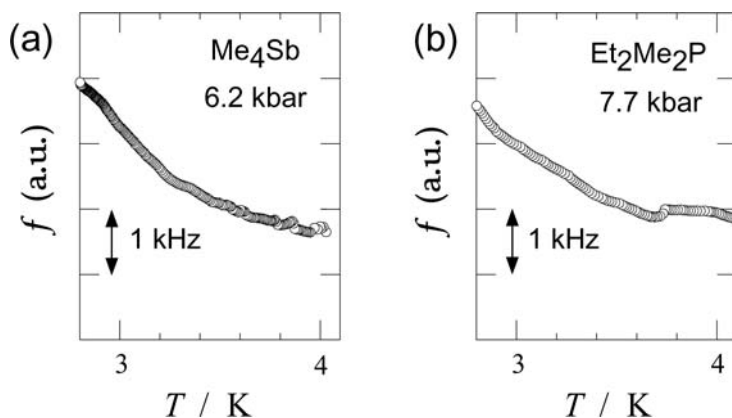


FIGURE 2 Temperature dependence of oscillation frequencies of $\text{Me}_4\text{Sb}[\text{Pd}(\text{dmit})_2]_2$ (a) and $\text{Et}_2\text{Me}_2\text{P}[\text{Pd}(\text{dmit})_2]_2$ (b).

For $\text{Me}_4\text{Sb}[\text{Pd}(\text{dmit})_2]_2$, a drop of resistivity suggesting superconducting transition near 10 kbar was previously reported^[3]. The drop of the resistivity is also reported by A. Eguchi *et al.* in the pressure region 6 - 8.5 kbar^[1]. In this pressure region, we observed a gradual increase of the frequency, as shown in Figure 2 (a). Similar behavior observed in the same method was reported by A. Eguchi *et al.*^[1]. We observed such behavior also for $\text{Et}_2\text{Me}_2\text{P}[\text{Pd}(\text{dmit})_2]_2$ (Figure 2 (b)). SC of this material is suggested to appear at 7 - 10.5 kbar by resistivity measurements^[2]. An important feature is the small amplitudes of the shielding signal of these two salts; they are about 10^{-2}

times as small as that observed in another organic superconductor $\kappa\text{-(BEDT-TTF)}_2\text{Cu}[\text{N}(\text{CN})_2\text{Br}]$ recorded using the same measurement system (Figure 3). It is also noticed that the temperature dependence of the RF shielding signals of the $[\text{Pd}(\text{dmit})_2]$ salts are anomalous, as compared with that of $\kappa\text{-(BEDT-TTF)}_2\text{Cu}[\text{N}(\text{CN})_2\text{Br}]$. In $\text{Et}_2\text{Me}_2\text{N}[\text{Pd}(\text{dmit})_2]_2$, we could not recognize any obvious signal in the pressure region 2.4 - 5 kbar, whereas SC was suggested to appear in this region^[4].

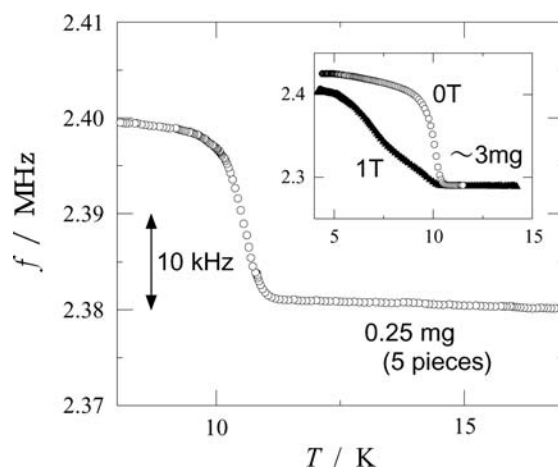


FIGURE 3 Typical RF shielding behavior of $\kappa\text{-(BEDT-TTF)}_2\text{Cu}[\text{N}(\text{CN})_2\text{Br}]$ observed by present method

To explain these results, some reasons are conceivable. If the SC occurs only in a certain conduction path or surface, then the conductivity measurement can observe drop of the resistance. On the other hand, the diamagnetic shielding probes the bulk behavior. Therefore, it is expected that the SC occurs only in a small part of a crystal in the studied $[\text{Pd}(\text{dmit})_2]$ salts. Distribution of T_c from crystal to crystal may also obscure a clear SC transition. A lower critical field

H_{c1} may be responsible for the weak shielding. Upper critical field H_{c2} of $\text{Et}_2\text{Me}_2\text{P}[\text{Pd}(\text{dmit})_2]_2$ is reported to be high when the field is applied parallel to the plane^[5], therefore, a low intra-plane H_{c1} of about 2 - 3 G is expected. Since the RF field in the coil is estimated to be about 2 - 3 G, the shielding effect may be obscured by the RF field during the measurement. However, the shielding signal is still too small, even though an isotropy of the sample mounting is taken into account. It is required to study magnetization process and the transport properties for various field direction, in order to clarify the SC in the $[\text{Pd}(\text{dmit})_2]$ salts, paying attention also to sample dependence.

Acknowledgments

We are grateful to Prof. Koji Kajita for encouragement. This work is supported by Grant-in-Aid for Scientific Research on Priority Area (A) of Metal-assembled Complexes (No. 401/10149249) and that (B) of Molecular Conductors and Magnets (No. 730/11224210) from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

References

- [1.] A. Eguchi, M. Tamura, Y. Nishio and K. Kajita, unpublished.
- [2.] R. Kato, Y. Kashimura, S. Aonuma, N. Hanasaki and H. Tajima, *Solid State Commun.*, **105**, 561 (1998).
- [3.] Y. Kashimura, *Ph.D. Thesis, University of Tokyo, Japan*, 1999.
- [4.] H. Kobayashi, K. Bun, T. Naito, R. Kato and A. Kobayashi, *Chem Lett.*, 1909 (1992).
- [5.] S. Rouziere, N. Hanasaki, R. Kato and H. Tajima, *Solid State Commun.*, **112**, 295 (1999).