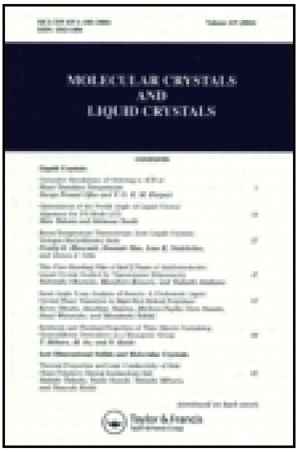

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Room Temperature Ferromagnetic Behavior in Pressed Pellets of Doped Poly (3-methylthiophene)

A. J. A. De Oliveira [a] , E. C. Pereira [b] , L. Walmsley [c] , A. A. Correa [b] , W. A. Ortiz [a] & L. O. S. Bulhòes [b]

[a] CMDMC Departamento de Física, Universidade Federal de S. Carlos, CP 676, São Carlos, SP, CEP 13565-905, Brazil

[b] CMCDM-LIEC Departamento de Química, Universidade Federal de S. Carlos, CP 676, São Carlos, SP, CEP 13565-905, Brazil

[c] Departamento de Física, IGCE, Universidadede Estadual Paulista, C.P. 178, Rio Claro, S.P., CEP 13500-970, Brazil

Version of record first published: 29 Oct 2010

To cite this article: A. J. A. De Oliveira, E. C. Pereira, L. Walmsley, A. A. Correa, W. A. Ortiz & L. O. S. Bulhòes (2002): Room Temperature Ferromagnetic Behavior in Pressed Pellets of Doped Poly (3-methylthiophene), Molecular Crystals and Liquid Crystals, 374:1, 385-390

To link to this article: http://dx.doi.org/10.1080/10587250210450

Mol. Cryst. Liq. Cryst., Vol. 374, pp. 385-390

1058-725X/02 $12.00 + .00

Room Temperature Ferromagnetic Behavior in Pressed Pellets of Doped Poly (3-methylthiophene)

A. J. A. DE OLIVEIRA[a], E. C. PEREIRA[b], L. WALMSLEY[c], A. A. CORREA[b], W. A. ORTIZ[a] and L. O. S. BULHÒES[b]

[a]*CMDMC Departamento de Física, Universidade Federal de S. Carlos, CP 676, CEP 13565-905 - São Carlos - SP – Brazil,*
[b]*CMCDM-LIEC Departamento de Química, Universidade Federal de S. Carlos, CP 676, CEP 13565-905 - São Carlos - SP – Brazil and*
[c]*Departamento de Física, IGCE- Universidadede Estadual Paulista C.P. 178 - CEP 13500-970 - Rio Claro - S.P.- Brazil*

Room temperature ferromagnetic behavior has been observed in pressed pellets of doped poly(3-methylthiophene). In this work we show that thermoremance data taken in two different ways favours the interpretation of data in terms of the Dzialoshinski-Moriya anisotropic superexchange interaction of the polarons via dopant anions giving rise to weak ferromagnetism.

Keywords: conducting polymers; polarons; weak ferromagnetism; antiferromagnetism .

INTRODUCTION

Recently we have observed room temperature ferromagnetic behavior in pressed pellets of partially reduced poly(3-methylthiophene) [1,2]. This behavior is characterized by a hysterisis curve with coercivity around 100 Oe and remanent magnetization of the order of 10^{-3} emu/g. We have exclude the possibility of contamination and shown that the magnetic response is intrinsic of the polymer. In order to explain the data we have proposed a Dzialoshinski-Moriya anisotropic superexchange interaction of the polarons via dopant anions giving rise to weak ferromagnetism [3]. Although this model would imply in a high degree of crystallinity in our pellets, it has in fact some experimental evidences. First, the ferromagnetic behavior increases with the pressure used to make the pellets and second, evidence of antiferromagnetic behavior [1,2] .In this work we show thermoremance data obtained in different ways that confirms the existence of both ferromagnetic and antiferromagnetic behavior in our samples. Besides this, we observe a tendence of the system to a low dimensional ferromagnetic behavior if the samples are cooled with an applied magnetic field.

EXPERIMENTAL

Poly(3-methylthiophene) (P3MT) was electrochemically synthesized and reduced as previously reported [1] with the level of reduction being controlled by the open circuit potential of the electrochemical cell. A complete range of V_{oc} values were tested, from the completely reduced sample, to the oxidized one. Samples for which V_{oc} = 0.35 V have the higher values of remanence. Pellets were prepared using an isostatic chamber, the powder being enclosed in a capsule of silicone ribbon. We have also studied the influence of water on the synthesis conditions. In the remainder of the text, we will refer to Sample A to designate specimens prepared with the addition of 200 ppm of water on the acetonitrile solution and isostatically pressed at 250 bar. Sample B represents specimens prepared without any addition of water, but also pressed isostatically at 250 bar. The magnetic measurements were performed using a Quantum Design SQUID magnetometer, model MPMS-5S.

RESULTS AND DISCUSSION

Figure 1 shows the thermoremance behavior of sample A. The sample was cooled from 296 K to 1.8 K without the application of a magnetic field. At 1.8 K a magnetic field H=500 Oe was applied for ten minutes and then removed. The data taken when the sample was heated at a rate of 2K/min (triangles) was fitted to $M(T)=M(0)-aT^{3/2}$ (dashed line). The extrapolation of the data to zero magnetization shows T_C = 810 K. In a second experiment the sample of cooled from room temperature to 1.8K with the application of a magnetic field of 500 Oe. At 1.8K the field was removed and the data collected raising the temperature (circles) and fitted to $M(T)= M(0)-bT^{1/2}+cT$ (solid line). The same expression was used to fit the data for a similar experiment of the one described above with sample A but with an applied field of 1000 Oe, is shown in Figure 2. (Squares) show the data and (dashed line) shows the fitted curve. For sample B (crosses) however the best fit (solid line) was $M(T)=M(0)-bT^{1/2}$. We can observe that in the first situation (sample cooled without a magnetic field) the thermoremance data shows magnetization decreasing with the usual $T^{3/2}$ behavior characteristic of

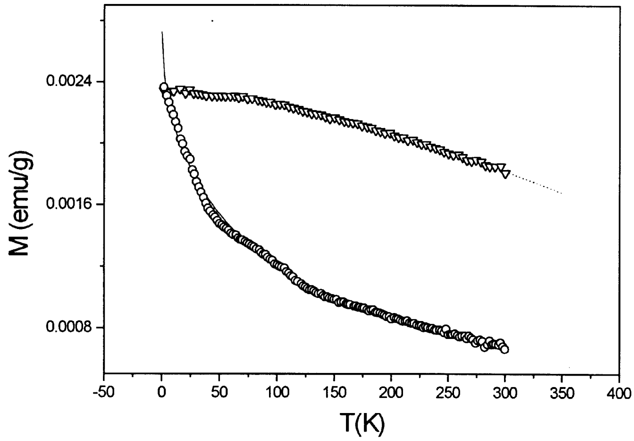

FIGURE 1 -Thermoremanence data for sample A with the sample cooled from 300K without the application of magnetic field (triangles). Data for sample cooled with a field H=500 Oe (circles).

three dimensional systems [4]. But, if the samples are cooled with an applied field, the data is fitted with magnetization decreasing with a $T^{1/2}$ behavior characteristic of one dimensional systems. In the case of sample A, in addition to this one-dimensional ferromagnetism, antiferromagnetism is also observed from the contribution of the term showing increase in the magnetization with T. Figure 3 shows the M x T curve for samples A (squares) and B (triangles) . The samples were cooled from room temperature to 1.8K without the application of a magnetic field (ZFC). At 1.8K a field of 100 Oe was applied and the data was collected raising the temperature. The ferromagnetic contribution is higher for sample A than for sample B. The antiferromagnetic contribution can now be observed for sample B. It starts around the same temperature (15 K) for both samples.

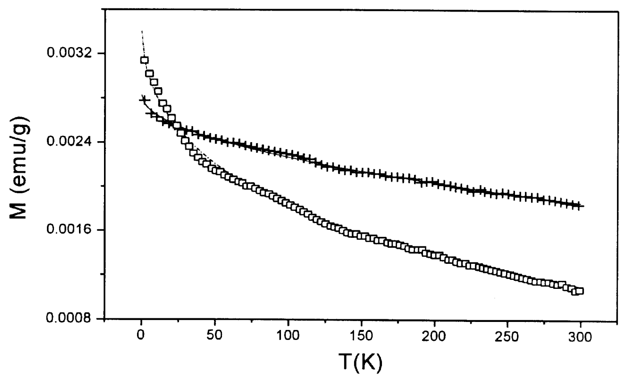

FIGURE 2 - Thermoremanence curves for samples A (squares) and B (crosses) cooled in an applied field H=1000 Oe.

This behavior of the thermoremance can be understood if we assume that the application of a field at room temperature favours in plane antiferromagnetic alignment of spins leaving a canted ferromagnetic.

contribution in the remaining direction. But when the sample is quenched without a magnetic field the random orientation of the chains allows ferromagnetic behavior to be observed.

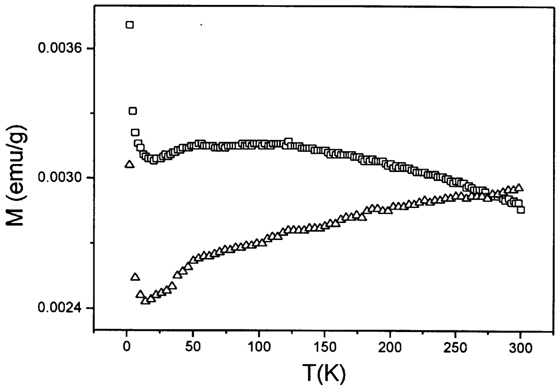

FIGURE 3 - Mx T curves for sample A (squares) and B (triangles). The data were collected cooling the samples with an applied field of 100 Oe.

ACKNOWLEDGMENTS

This work was partially supported by brazilian agencies FAPESP, CEPID/FAPESP, CNPQ and PADCT-III/CNPq.

REFERENCES

1-A.A. Correa, L. Walmsley, L.O.S. Bulhões, W.A. Ortiz, A.J.A. de Oliveira and E.C. Pereira. Synth. Met.121 (1-3) 1836 (2001).
2- E.C. Pereira, A.A. Correa, L.O.S. Bulhões, P.C. Aleixo, J.A. Nóbrega, A.J.A. de Oliveira, W.A. Ortiz and L. Walmsley. J. of Mag. Magnet. Mat. 226-230, 2023 (2001).
3- T. Morya, Weak Ferromagnetism in Magnetism , Vol 1 (G.T. Rado and H. Suhl editors) Academic Press, London (1963).
4- C. Kittel, Introduction to Solid State Physics (Wiley) (1995).