3. Christie, D. M. and Sinton, J. M., *Earth Planet. Sci. Lett.*, 1981, **56**, 321–355.
4. Langmuir, C. and Bender, J. F., *Earth Planet Sci. Lett*, 1984, **69**, 107–127.
5. Langmuir, C., Bender, J. F. and Batiza, R., *Nature*, 1986, **322**, 422–429.
6. Kalyayev, G. I., Karabovich, S. V., Rusakov, O. M and Startostenkov, V. I., *Geotectonics*, 1983, **17**, 32–42.
7. Pluger, W. L., *Fahrtbericht SO-28 und Wissenschaftlicher Bericht GEMINO-I. Geothermal Metallogenesis Indian Ocean*, 1988, p. 274.
8. Chaubey, A. K., Krishna, K. S., Subba Raju, L. V. and Rao, D. G., *Deep-Sea Res.*, 1990, **37**, 647–656.
9. Mitchell, N. C. J., *J. Geophys. Res.*, 1991, **96**, 8019–8043.
10. Herzig, P. M. and Pluger, W. L., *Can. Mineral.*, 1988, **26**, 721–736.
11. Banerjee, R. and Iyer, S. D., *Indian J. Mar. Sci*, 1989, **18**, 124–127.
12. Banerjee, R. and Iyer, S. D, *J. Geol. Soc. India*, 1991, **38**, 369–386.
13. Iyer, S. D. and Banerjee, R., *Geo-Mar. Lett.*, 1993, **13**, 153–158.
14. Macdonald, K. C., Scheirer, D. S. and Carbotte, S. M., *Science*, 1991, **253**, 986–994.
15. Atwater, T. M., in *Deep Drilling Results in the Atlantic Ocean* (eds. Talwani, M, Harrison, C. G. and Hayes, D. E.), Am. Geophys. Union, 1979, pp. 233–242.
16. Minster, J. B. and Jordan, T. H, *J. Geophys. Res.*, 1978, **83**, 5331–5354.
17. Mukhopadhyay, R. and Khadge, N. H., *Proc. Indian Acad. Sci. (Earth Planet. Sci.)*, 1990, **99**, 357–365.
18. Macdonald, K. C., *Annu Rev. Earth Planet Sci.*, 1982, **10**, 155–190.
19. Bonatti, E. and Hamlyn, P. R., in *The Sea* (ed. Emiliani, C.) John Wiley and Sons, New York, 1981, vol. 7, pp. 241–283.
20. Mutter, J. C. and Karson, J. A., *Science*, 1992, **257**, 627–634.
21. Flower, M. F. J., *Nature*, 1980, **287**, 530–532.
22. Green, D. H. and Ringwood, A. E., *Contrib. Mineral. Petrol.*, 1967, **15**, 103–190.
23. Klein, E. M. and Langmuir, C. H., *J. Geophys. Res.*, 1987, **92**, 8089–8115.
24. Royer, J. Y., Sclater, J. G and Sandwell, D. T., *Proc. Indian Acad. Sci. (Earth Planet. Sci.)*, 1989, **98**, 7–24.

ACKNOWLEDGEMENTS. We thank R. R. Nair for suggestions, other members of GIOTAS group Drs R. Banerjee, S. M. Karisiddaiah and A. V. Mudholkar for help in the initial stages of this work, and U. Javali for drafting the figures. R. M. thanks CSIR for deputing him to participate in the GEMINO cruises onboard *FS Sonne*. We thank the referee for a helpful review.

Received 20 March 1993, revised accepted 21 May 1993

RESEARCH COMMUNICATIONS

Resistivity studies of metal complexes of lignocaine hydrochloride

A. Indira, S. B. Bellad, A. M. Babu, M. A. Sridhar and J. Shashidhara Prasad

Department of Studies in Physics, University of Mysore, Manasagangothri, Mysore 570 006, India

The temperature dependence of resistivities of the complexes lignocainehydrochloride–chromium (CRL), monochlorotrinitro copper(II) lignocaine (CUNL) and lignocainehydrochloride–manganese (MNL) has been studied. All the compounds exhibit semiconducting behaviour which can be accounted for by the stacking of the donor and acceptor molecules in the crystal structure. The degree of fall of resistivity of the compounds decreases in the order MNL, CRL, CUNL. The complex CUNL shows appreciable conductivity in the temperature range 234–279 K, as well as in the range 388–468 K. This behaviour might be attributed to the phase transition (if it exists) of the complex at a lower temperature.

LIGNOCAINE hydrochloride (LH), an important acetamide derivative, is commercially known by different names, viz. Xylocaine, Lidocaine and Gescicaine. Its chemical name is 2-(diethylamine)-*N*-(2,6-dimethylphenyl)acetamide hydrochloride. It is the most common and important local anaesthetic and anti-arrhythmic drug. In order to obtain a deeper insight into the function, activity and properties of LH, we have taken up X-ray crystallographic studies of a number of charge transfer complexes of LH with various metals like Pt, Co, Cu, Fe, in the form of platinum chloride[1], cobalt · chloride[2], copper chloride[3] and ferric chloride[4]. As a continuation of this, we have undertaken a study of the variation of resistivity as a function of temperature for lignocainehydrochloride–chromium complex (CRL), monochlorotrinitro copper(II) lignocaine complex (CUNL) and lignocainehydrochloride–manganese complex (MNL).

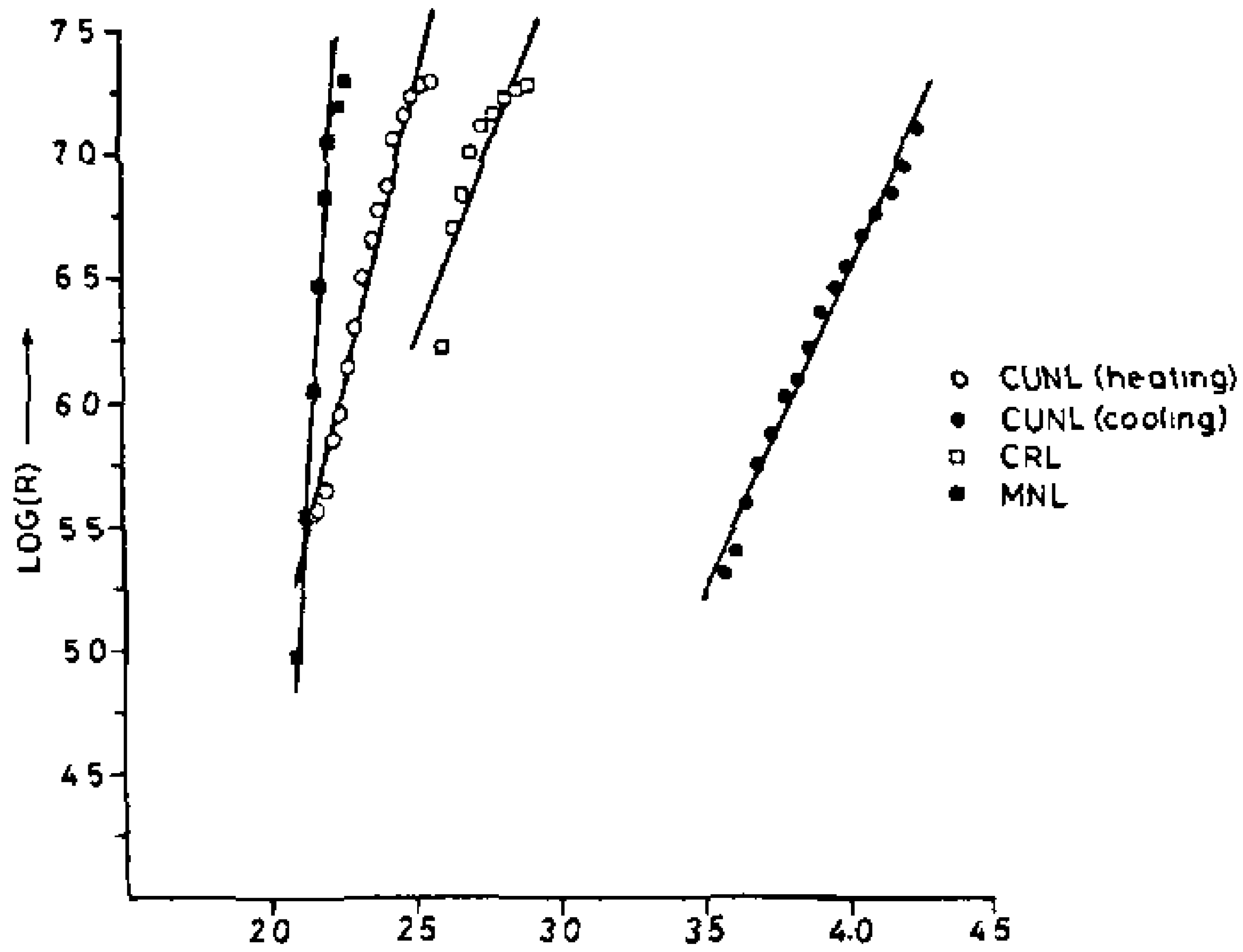

Figure 1. Log(R) vs $1/T$ plot.

Table 1. Activation energies of the complexes studied

Complex	Slope of log(R) vs $1/T$ plot	Correlation coefficient	Activation energy (eV)
CRL	2968.54	0.80	0.5892
CUNL (388–468 K)	4655.50	0.97	0.9240
CUNL (234–279 K)	2541.87	0.98	0.5045
MNL	16585.10	0.97	3.2916

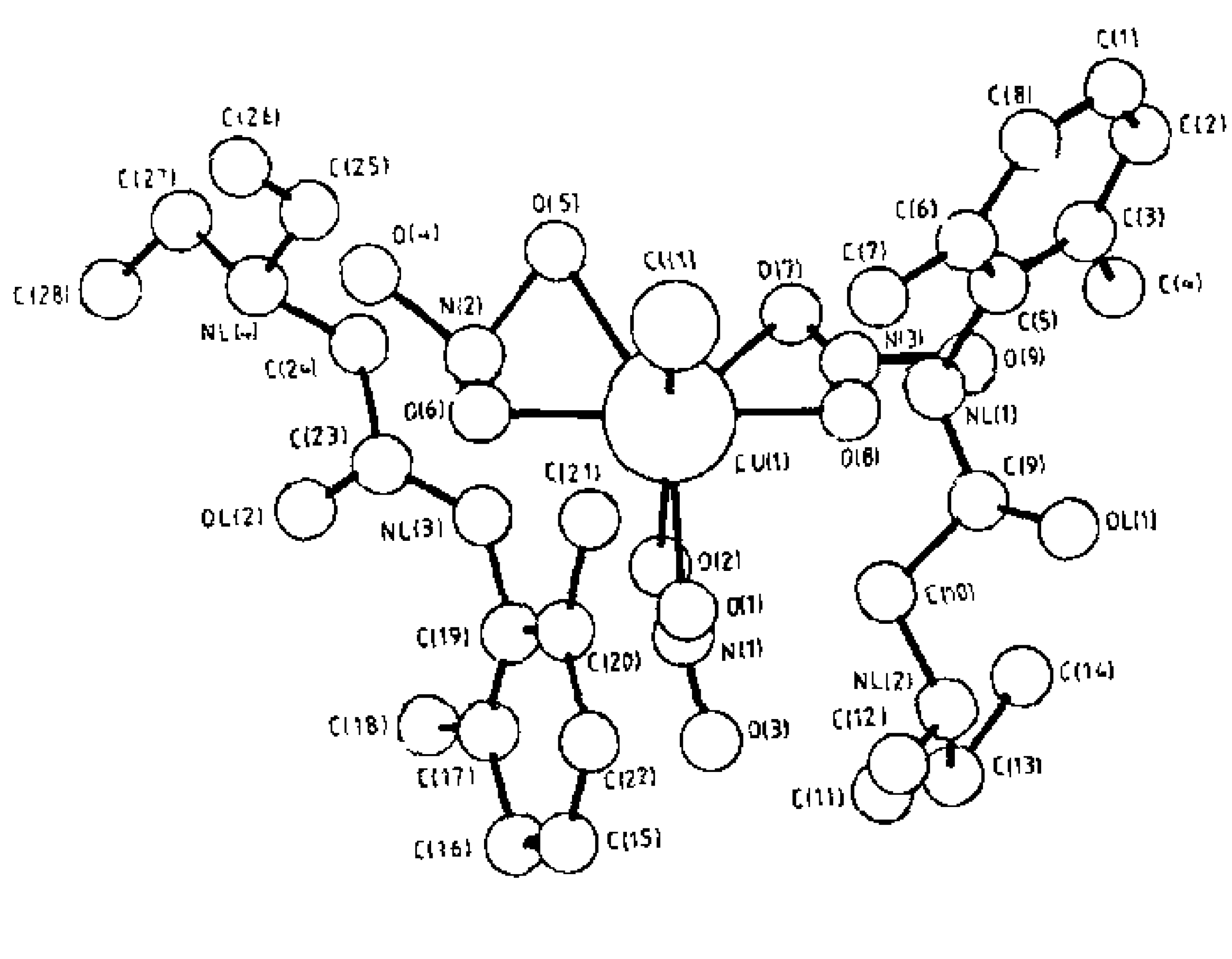

Figure 2. Projection of the molecule (CUNL) on the best plane

The resistance measurements of the complexes under study were carried out on single crystals using the two-probe technique with silverized contacts. Low-temperature measurements have been done for CUNL complex using bath-type liquid-nitrogen cryostat in the range 230–300 K. High temperature measurements for all the complexes were made in the range 300–470 K. Keithley 616 digital electrometer having an accuracy of ± 5% of the reading was used. Temperature controller DRC80C from Lake Shore Cryotronics Inc. was used to measure low temperatures. High temperatures were measured with chromel–alumel thermocouple (K type) with a digital temperature controller having an accuracy of ±1% of the reading

The resistance of the CUNL complex in the low-temperature region ranges from 10^3 to $10^6\,\Omega$ and the resistance of the complexes CRL, CUNL, MNL in the high temperature region ranges between 10^3 and $10^6\,\Omega$. The degree of fall of resistivity decreases in the order MNL, CRL, CUNL. An exponential variation of the resistance with temperature is observed in all the complexes according to the equation $R = R_0 \exp(-E_a/kT)$, where E_a is the activation energy and k the Boltzmann constant. This is evident from the log(R) vs $1/T$ plots shown in Figure 1. The activation energy values of the complexes are given in Table 1. The complex CUNL shows appreciable conductivity in two regions, one below room temperature and the other above room temperature. The structural analysis of this compound reveals an uncommon seven coordination for the copper atom. It is bound to seven atoms – six oxygen atoms of the three nitrate groups and one chlorine atom. The structure of the complex at room temperature is shown in Figure 2 (ref. 5). It may be surmised that this behaviour in conductivity may be due to a structural phase transition at a lower temperature. This aspect is being currently investigated.

1. Bellad, S. B., Sridhar, M. A., Babu, A. M., Indira, A., Shashidhara Prasad, J., Ramappa, P. G. and Nagendrappa, G., *Z. Kristallogr.*, 1992, **202**, 33–39.
2. Indira, A. I., Babu, A. M., Bellad, S. B., Sridhar, M. A. and Shashidhara Prasad, J., *Z. Kristallogr.*, 1992, **202**, 286–289.
3. Sridhar, M. A., Babu A. M., Indira, A., Bellad, S. B., Shashidhara Prasad, J., Ramappa, P. G. and Nagendrappa, G., *Z. Kristallogr.*, 1992, **202**, 292–295.
4. Babu, A. M., Sridhar, M. A., Bellad, S. B., Indira, A., Abdoh, M. M. M. and Shashidhara Prasad, J., *Z. Kristallogr.*, 1992, **203**, 161–166
5. Indira, A., Babu, A. M., Bellad, S. B., Sridhar, M. A., Shashidhara Prasad, J. and Prout, C. K., *Curr. Sci.*, 1993, **64**, 247–252.

ACKNOWLEDGEMENTS. A. I., S. B. B., A. M. B. and M. A. S. thank UGC, New Delhi, and J. S. P. thanks DST, New Delhi, for financial assistance. We thank Prof. P. G. Ramappa, Department of Studies in Chemistry, University of Mysore, Mysore for kindly providing the samples. We also thank Prof. S. V. Subramanyam, Department of Physics, Indian Institute of Science, Bangalore, for the facilities provided.

Received 14 August 1992; revised accepted 14 June 1993

A 20-kD mitochondrial protein is associated with cytoplasmic male sterility (CMS) in *Capsicum annuum* L.

M. Manoharan, K. U. Pai* and C. K. Rudramuniyappa

Department of Botany, Karnatak University, Dharwad 580 003, India
*Molecular Biology and Agriculture Division, Bhabha Atomic Research Centre, Bombay 400 085, India

Mitochondria from normal and cytoplasmic male sterile (CMS) lines of *Capsicum annuum* L. were isolated and allowed to synthesize proteins in the