

electrical resistivities are supposed to vary because of variations in the band gap and therefore, high pressure studies on these complexes are important to carry out.

Organic charge transfer complexes and inclusion compounds of iodine were prepared using standard methods of mixed solutions [6–10].

Low temperature and high pressure measurement on resistivity were carried out using continuous flow cryostat and Bridgmann anvil apparatus [11–15].

Results of DC/AC resistivity measurements on compounds like α -cyclodextrine- $\text{KI-I}_2 \cdot 4\text{H}_2\text{O}$, amylose-iodine and similar other compounds like DTN-I_2 , anthracene-TNB (TNB-trinitrobenzene), (coumarin) $_4$ - KI-I_2 , pyrene- 2I_2 etc are plotted in Figures (1–6).

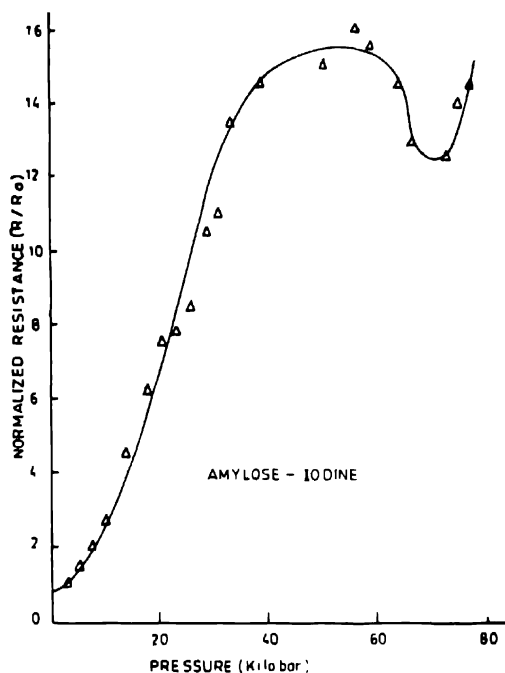


Figure 1. Pressure dependence of resistivity of amylose-iodine.

This paper is devoted to detailed analysis and plausible interpretations based on theoretical models related to resistivity of similar compounds under different physical conditions like pressure and temperature. Section 2 describes plausible theoretical models that explain the experimental results. Section 3 reviews the other theoretical models. The temperature characteristics of the resistivity of various compositions of benzidine-iodine complexes are discussed in Section 4. Conclusions are drawn by highlighting the main results in Section 5.

An increase followed by the flattening of the resistivity peaks are observed in α -cyclodextrine- $\text{KI-I}_2 \cdot 4\text{H}_2\text{O}$, amylose-iodine and (coumarin) $_4$ - KI-I_2 under high

pressure [16]. Flat peaks observed in DTN and DTN-I₂ (see Figure 2) are similar to those in CdS, cerium and graphite [16]. Symmetric peaks observed in anthracene-TNB

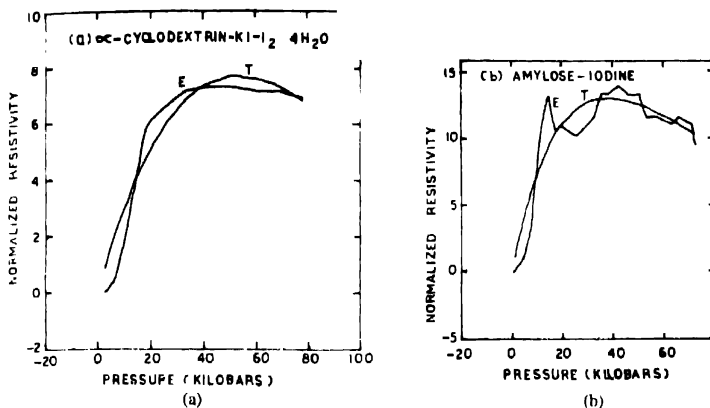


Figure 2. Experimental (E) and theoretically (T) fitted plots according to eq. (19) for the two inclusion compounds :

(a) α -cyclodextrine-KI-I₂·4H₂O . $A = 24.49516$,
 $b = -0.00059$ (k bar)⁻¹, $c = 0.01122$ (k bar)⁻¹,
 $K = 0.60515$ (k bar)⁻¹

(b) Amylose-iodine $A = 1.76575$, $b = -0.00060$
 (k bar)⁻¹, $c = 0.02739$ (k bar)⁻¹, $K = -0.88239$
 (k bar)⁻¹

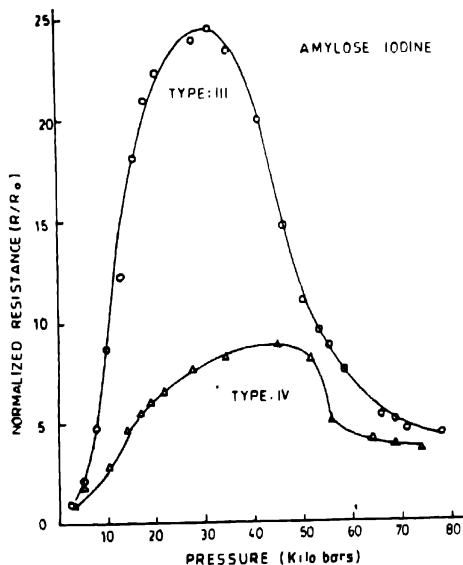


Figure 3. Pressure dependence of resistivity of a pellet of an iodine complex.

and pyrene-2I₂ (see Figure 4) are also similar to those in metals like Ca, Sr, Neodymium, Zn and Cd [16]. Two peaks as observed here in α -cyclodextrine-KI-I₂·4H₂O and amylose-

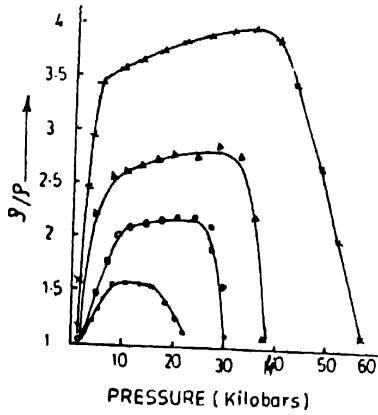


Figure 4. Pressure dependence of resistivity of DTN and DTN-I₂ (DTN = dithionaphthalene)

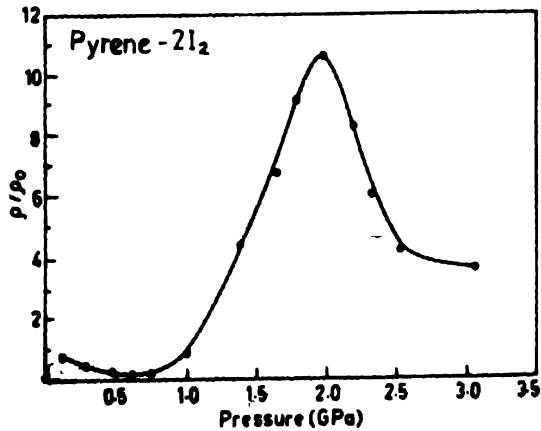
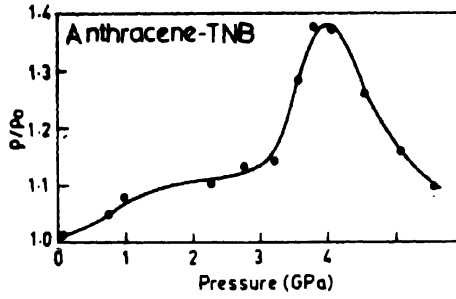


Figure 5. Pressure dependence of resistivity of anthracene-TNB and pyrene-2I₂.

iodine at 1000 Hz are also similar to the resistivities of cesium and europium [16]. Amylose-iodine prepared by different methods are designated as types I to IV and differ in dimensionality.

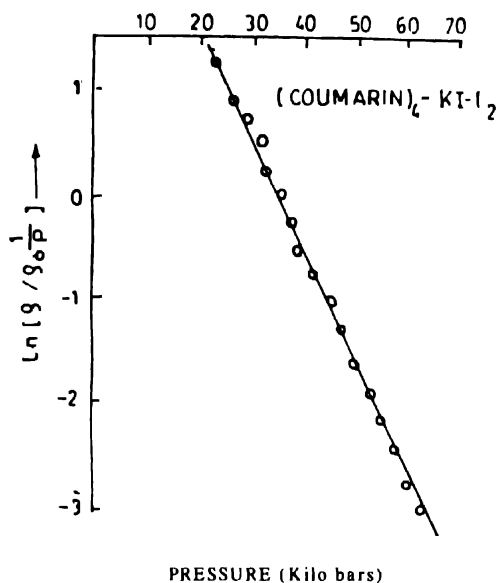


Figure 6. Pressure dependence of resistivity of (coumarin)₄-KI-I₂.

2. Analysis based on theoretical models

An increase in electrical resistivity of organic polyiodide chain complexes at high pressures was qualitatively discussed earlier [15]. However, the observation of decreasing tail and in some cases, the second increase at high pressure were never discussed before. The exponent conductivity as $\sigma \sim (P - P_C)^{\gamma}$ failed to show percolation mechanism of any dimensionality in the high pressure range. There is a possibility of transformation of a direct band gap to indirect band gap at high pressures. In this case, crossing of valleys is a plausible mechanism for the interpretation of high pressure results as the case for elemental and compound semiconductors (Ge, Si, GaAs, SiC etc) [17,18]. The effective mass of charge carriers changes when the crossing of valleys occur. It is a dimensional cross-over and dimensionality increases. This is because charge carriers along different crystallographic directions are mixed up [19]. Flat peak observed in DTN and DTN-I₂ at zero frequency and in α -cyclodextrin-KI-I₂ and amylose-iodine at 1000 Hz (Figure 2) reveal crystallographic effect because such crystallographic effect is observed in the generalization of Blackmann approximation supporting crossing of valleys as a mechanism of crystal structure effects [20,21].

Two or three dimensional phonons are involved at high pressure and electron-phonon interaction leads to a change in dimensionality of conduction. Direct band gap semiconductors become an indirect band gap semiconductors involving phonons at high pressures.

The symmetric peaks observed in the dc resistivity *versus* pressure for anthracene-TNB and pyrene-2I₂ and the ac resistivities at 1000 Hz for α -cyclodextrin-KI-I₂·4H₂O and amylose-iodine under relatively low pressure range seemed to obey the expression given by

$$\frac{\rho}{\rho_0} = A + BP^{*2} (1 - P^*)^2, \quad (1)$$

where P^* is the pressure range from where the symmetric peak is prominent, while at relatively higher pressure range, the flat peaks observed in the ac resistivities at 1000 Hz of the α -cyclodextrin-KI-I₂ and amylose-iodine and the dc resistivities observed in DTN and DTN-I₂ seem to obey

$$\frac{\rho}{\rho_0} = A + BP^{*1/2} (1 - P^*)^{1/2}. \quad (2)$$

It would be interesting to see the physical basis for the typical pressure dependence on resistivity of these organic compounds. For ionic compounds like pyrene-2I₂ and anthracene-TNB the conduction current is due to real part of the electric polarizability given by

$$\text{Real}[J] = N[\omega\alpha'_c]E_0 \quad (3)$$

$$\alpha''_c = \frac{e^2\omega\beta/m^{*2}}{\left[(\omega_0^2 - \omega^2)^2 + \left(\frac{\omega\beta}{m^*} \right)^2 \right]}, \quad (4)$$

where β is the damping parameter proportional to ω^2 and m^* is the effective mass [20]. From the basic relation that $J = \sigma E$, the resistivity can be expressed as

$$\rho = A \frac{\left[(\omega_0^2 - \omega^2)^2 + (\omega\beta/m^{*2})^2 \right]}{[\omega^2\beta/m^{*2}]}. \quad (5)$$

Here, ω 's are the phonon frequencies generated under the external pressure and it is proportional to $p^{1/2}$. The effective mass of the charge carrier also varies with external pressure. According to the non-degenerate perturbation theory for coupled bands for complex systems, the effective mass has shown to vary as [21] $1/m^* \sim (2\hbar^2/m^2a^2)/\Delta E$, where a corresponds to the variation in the average lattice spacing under external pressure. We assume here that the change in lattice spacing at moderately

low pressure range may be proportional to p . Thus, the change in m^* under a pressure difference p is quadratic. Putting it back in the expression given by eq. (4) leads to

$$\frac{\rho}{\rho_0} = \frac{K^2(p_0 - p)^2 m^{*2} + c^2 p^3}{Ae^2 p^2} \quad (6)$$

$$= \frac{K^2}{Ae^2} p^2 (p_0 - p)^2 + \frac{c^2 p}{Ae^2}. \quad (7)$$

The leading term in eq. (7) is similar to eq. (1), providing a theoretical basis for symmetric peak observed in these compounds.

The expressions given in eq. (2) corresponding to flat peak can also be found to arise from the basic definition for resistivity,

$$\rho = \frac{1}{ne\mu}, \quad (8)$$

where n is the density of charge carrier and μ is the mobility. The mobility μ is given by [22]

$$\mu = \frac{e\tau}{m^*} = \frac{e\lambda v}{m^* v}, \quad (9)$$

where λ is the mean free path, v is the collision frequency, v is the average velocity related to the group velocity for the acoustic phonons because under relatively high pressure, strong electron-phonon coupling form a condensate and travel with the same velocity. Using the dispersion relation for acoustic phonons we get

$$\rho = \frac{m^*}{ne^2 \lambda v} \frac{a}{2} (\omega_m^2 - \omega^2)^{1/2}, \quad (10)$$

where a is the change in the mean lattice spacing under pressure. The carrier concentration n is given by the Boltzmann distribution

$$n = n_0 \exp(-\epsilon_a / kT), \quad (11)$$

here ϵ_a is the activation energy of the compound. We may show a logarithmic variation in ϵ_a with pressure (at a later stage) providing a direct variation of n with pressure. Thus, change in mean lattice spacing assumed to go linearly with pressure and the effective mass, v and ω to vary with pressure in the same way discussed before, leads to the form

$$\frac{\rho}{\rho_0} \sim p^{1/2} (p_0 - p)^{1/2}, \quad (12)$$

as expected from eq. (2).

For detail analysis of conductivity variations by pressure, we consider the most general expression for conductivity as given by eq. (8) as

$$\sigma = ne\mu. \quad (13)$$

Under the external pressure, the effective change in the conductivity due to the respective variations in n and μ is given by

$$\frac{d\sigma}{dp} = e\mu \frac{\partial n}{\partial p} + en \frac{\partial \mu}{\partial p}. \quad (14)$$

The variation in n under pressure is through the variation in the activation energy through eq. (11). Similarly, the variations in mobility is through the parameters in the eq. (9) defining the mobility.

Using eq. (11), eq. (14) can be written as

$$\frac{d\sigma}{dp} = en \left[\frac{-\mu}{kT} \frac{\partial \epsilon_a}{\partial p} + \frac{\partial \mu}{\partial p} \right]. \quad (15)$$

The variation of resistivity with pressure is given by

$$\frac{d\rho}{dp} = -\frac{1}{\sigma^2} \frac{\partial \sigma}{\partial p} \quad (16)$$

$$= \rho_0 \exp \left[\frac{\epsilon_a}{kT} \right] \left(\frac{\mu_0}{\mu kT} \frac{\partial \epsilon_a}{\partial p} - \frac{\mu_0}{\mu^2} \frac{\partial \mu}{\partial p} \right). \quad (17)$$

Here n_0 is available electrons in the valance band which does not change with pressure; n_0 changes in such manner that resistivity decreases unless pressure leads to a back transition from conduction band to valance band when pressure increases. Mobility is related to mean free path and collision frequency which can change with pressure [22]. Even diffusion coefficient (D) can change with pressure. Mobility depends on pressure through the collision time as well as m^* given by eq. (9).

The dependence of pressure will also attribute upon whether electron gas is degenerate or non-degenerate and is very complicated. Due to the lack of trust-worthy theoretical description of electrical properties of complex organic and organometallic compounds under pressure, we fit the experimental data for crystals of α -cyclodextrin-KI- $I_2 \cdot 4H_2O$, amylose iodine and (coumarin) $_4$ -KI- I_2 by an analytical expression :

$$\frac{\rho - \rho_0}{\rho_0} = A + \left[\frac{Bp}{(1 + bp)} - A \right] \exp(-cp). \quad (18)$$

The constants A , B , b and c are fitted parameters. This expression can also be written as

$$\frac{\rho - \rho_0}{\rho_0} = A + \frac{K(p - A/K)}{(1 + bp)} \exp -c(p - A/K) e^{-cA/K}, \quad (19)$$

where $K = B - Ab$ (Figure 2).

For pellet, $A = b = 0$ and we get (Figure 4)

$$\frac{\rho - \rho_0}{\rho_0} = Kp \exp(-cp), \quad (20)$$

which can be thought to arise out of Maxwellian because $\rho = (1/3)mnv^2$. This dependence of pressure on the resistivity has been found experimentally (see Figure 7). In the case of single crystals, it is a shifted Maxwellian weighted by $(1 + bp)$ term in the denominator. This denominator term can be understood using a charge carrier residing on a harmonic oscillator of lattice vibration.

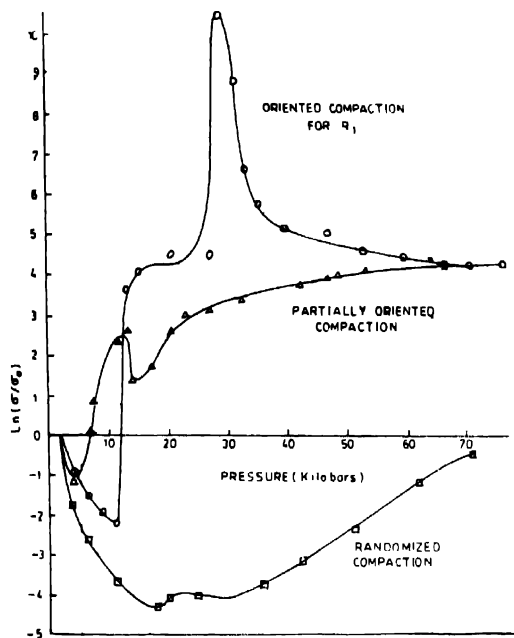


Figure 7. Conductivity vs pressure for (coumarin)₄-KI-I₂.

We consider that the mean free path is limited to the wavelength of charge density wave generated by the strong electron-phonon coupling and collision frequency is independent of pressure as it can be replaced by natural frequency of charge density wave. In this situation, $mv = \hbar k$ and $\lambda = 1/k$ gives

$$\rho = \frac{\hbar k^2}{ne^2 v} = 2m^*(E - V) \frac{1}{\hbar ne^2 v} \quad (21)$$

Now, the momentum is lost to the screened Coloumb potential developed in a distorted lattice at high pressure because of strain. Then

$$\rho = \left[\frac{2m_e^* E}{n_0 e^2 v \hbar} - \frac{2m_e^*}{\hbar n_0 e^2 v} \left(\frac{e^2 \exp - \lambda(r_n + r_0)}{r_n + r_0} \right) \right] e^{Ea/kT}, \quad (22)$$

where $r_n = na$; a being lattice constant, λ is Thomas-Fermi screening constant and r_0 is a constant. Within tight binding method, we find that m^* is also independent of pressure in

the required range. Substituting $a = a_0 [1 + \alpha / p - p_0]$ and expanding the exponential in $E_a = E_a^0 - \beta(p - p_0)$, we get exactly the required form of shifted Maxwellian. Here, the first term is independent when the total energy is constant by conservation law, then

$$\rho = \frac{2m^* \alpha}{n_0 v \hbar} (p - p_0) \frac{e^{-\lambda(na_0 + b)} e^{-\lambda na_0 \alpha (p - p_0)}}{[na_0 \{1 + \alpha(p - p_0)\} + b]}, \quad (23)$$

the change in the kinetic energy of charge carriers is related with Peierls transition at high pressure. The activation energy changes by 0.07 eV at high pressure which gives the order of Peierls gap found in one-dimensional conductors.

Now, consider a non-equilibrium process at high pressure in which both density of state and also the Fermi level change under pressure [15].

$$E_a = E_a^0 + \frac{dE}{dN} \Delta n = E_a^0 + \frac{\Delta n}{c(E - \mu)}, \quad (24)$$

where Δn is change in number of states, C is a constant and μ is the Fermi level using $dn/dE = D(E) = C|E - \mu|^n$ for $n = 1$ for a one-dimensional system. Now to find the total change, we integrate over μ which gives

$$\begin{aligned} E_a &= E_a^0 + \frac{D_0}{c} [\ln |E| - \ln |E - E_0|] \\ &= E_a^0 + \frac{D_0}{c} [\ln \beta p - \ln \beta(p - p_0)], \end{aligned} \quad (25)$$

where β is a constant relating pressure and energy. This is obtained from supply of elastic energy as a work done by pressure. When this energy goes over exponential gives

$$\rho = \rho_0 \exp(E_a / kT) = \frac{KP}{(1 + bp)} \exp(-cp),$$

where $K = \rho_0 \exp(E_a^0 / kT) \frac{D_0}{c} \frac{1}{p_0}$

and $c = \alpha E_c / kT$

and $b = \frac{-1}{p_0}$. (26)

This is the required form.

Thus there are two effects in single crystals : (1) due to a shift in kinetic energy one gets shifted in Maxwellian velocity, (2) the $(1 + bp)$ term in the denominator arises out of electronic or ionic polarizability. From eq. (19), we obtain

$$\frac{d\rho}{dp} = \rho_0 \exp - [cp + \ln(1 + bp)] \left[K - (Kp - A) \left(c + \frac{b}{1 + bp} \right) \right]. \quad (27)$$

Now comparing eq. (27) with eq. (17), we identify

$$\frac{E_a}{kT} = cp + \ln(1 + bp), \quad (28)$$

providing the required logarithmic pressure dependence. From eq. (28), we further get

$$\frac{\partial E_a}{\partial p} = kT \left[c + \frac{b}{1 + bp} \right]. \quad (29)$$

We identify from eqs. (17) and (27)

$$\frac{\mu_0}{\mu} = Kp - A \quad (30)$$

and
$$-\frac{\mu_0}{\mu^2} \frac{\partial \mu}{\partial p} = K. \quad (31)$$

Thus, a consistency between the eq. (17) and fitted analytical expression has been obtained.

Thus for these compounds the mobility goes as $1/(Kp - A)$. The values of $(dE_g/dp)_T$ are calculated with $E_g = 2E_a$ for α -cyclodextrin-KI-I₂-4H₂O, amylose-iodine and (coumarin)₄-KI-I₂, keeping other parameters unchanged. The values for Γ , X and L are tabulated (see Table 1) which should be compared with the similar values for elemental and

Table 1. Pressure coefficients of energy gap from pressure dependence of resistivity for polyiodide chain complexes

Complex	$(\partial E_g / \partial p)_T \times 10^6 \text{ eV} \cdot \text{cm}^3 / \text{kg}$		
	Γ	X	L
α -Cyclodextrin-KI-I ₂ -4H ₂ O	0.432	-0.036	-
Amylose-iodine (Type I)	0.672	-0.060	-
Amylose-iodine (Type II)	0.321	-0.207	0.104
(Coumarin) ₄ -KI-I ₂	0.80	-0.042	-

compound semiconductors [17]. These values are one or two orders of magnitude less than those for elemental and compound semiconductors. However Γ , X and L remain conduction band minima related with $K = 000$, 100 and 111 valleys. Within the localisation model the activation energy is given by

$$E_a = \frac{1}{\rho(E_F)R}, \quad (32)$$

where $\rho(E_F)$ is the average density of states at Fermi level and R is the hopping distance.

It may be realized that the linear plus logarithmic dependence and activation energy (eq. 28) on pressure arise through the distortion in the density of states in the energy bands of the sample compound. For example, the cosine potential leads to logarithmic fluctuations in activation energy through density of states [23].

3. Alternative physical mechanisms

In this section, we would like to see the possible physical mechanisms supporting the plausible physical processes described in Section 2. For weakly disordered one-dimensional alloy, density of state for one type site is given by

$$n_A(E) = \frac{1}{\pi [4t^2 - (\epsilon - \epsilon_A)]^{1/2}} \quad (33)$$

for ϵ lies between $\epsilon_A - 2t$ and $\epsilon_A + 2t$. Here, ϵ_a is the energy of a site and t is the hopping matrix element for site-diagonal disorder [24]. Conductivity should be proportional to the density of states and pressure changes elastic energy in a linear fashion as work is done. Also resistivity will be proportional to mean localization length. Localization with energy [24] and resistivity with pressure change alike. This shows that pressure leads to a change in elastic energy which tracks a band gap.

On the other hand, interpretation of contraction for Slater orbitals [25] is also applicable because the pressure dependence fits functional form of Slater orbitals which are described by

$$R(r) = Nr^{n-1} e^{-\mu'r/a_0}, \quad (34)$$

μ' and a_0 are constants.

The resistivity is related with charge density $e|R|^2$ as follows

$$\rho = \frac{1}{Q\mu} = \frac{1}{e|R|^2\mu}. \quad (35)$$

Using the linear coefficient of compression in as $r = r_0 [1 + \alpha(p - p_0)]$ where α is coefficient of compression and for $5p\sigma$ hybridization along iodine chains, $n = 5$ gives

$$\begin{aligned} \rho &= \frac{1}{e\mu} N^2 r^{-8} \exp(2\mu'r/a_0) \\ &= \frac{1}{e\mu} N^2 r_0^{-8} [1 + \alpha(p - p_0)]^{-8} \exp\left[\frac{2\mu'r_0}{a_0} (1 + \alpha(p - p_0))\right]. \end{aligned} \quad (36)$$

Here we may consider Bohr radius a_0 as independent of pressure and for small α , $[1 + \alpha(p - p_0)]^{-8} \approx [1 - 8\alpha(p - p_0)]$. Then the resistivity can be written as

$$\rho = (A + Bp)e^{-Cp}, \quad (37)$$

where
$$A = \frac{1 + 8\alpha}{e\mu N^2 r_0^8} \exp\left(\frac{2\mu'r_0}{a_0} (1 - \alpha p_0)\right),$$

$$B = \frac{-8\alpha}{e\mu N^2 r_0^8} \exp\left(\frac{2\mu'r_0}{a_0} (1 - \alpha p_0)\right)$$

and
$$C = \frac{2\mu'r_0\alpha}{a_0}. \quad (38)$$

The constants A and B contain mobility μ which is in general, pressure-dependent, but we neglect this dependence here. Then, we get the resistivity expression almost similar to the form we obtained from experimental fit.

Alternative interpretation comes from Gunn effect in semiconductors which has been observed in a large number of compound semiconductors. Under hydrostatic pressure, the inter-valley energy separation can be made less than the energy band gap and the Gunn effect dominates at all pressures. Here, pressure changes wave vector k and E versus k is tracked because this dependence is similar to resistivity vs pressure in crystals.

We also prove here that lever rule applicable to (coumarin)₄-KI-I₂ can be derived out of a dielectric constant formula in solid state physics, *i.e.*

$$\epsilon(\omega) = \epsilon_{\infty} \left(\frac{\omega_L^2 - \omega^2}{\omega_T^2 - \omega^2} \right) = \epsilon_{\infty} \left(\frac{P_L - P}{P_T - P} \right), \quad (39)$$

because $\omega^2 \sim p$. Now, the band gap E_g is related with dielectric model within Penn's model [27] as

$$\epsilon - 1 = \frac{\hbar^2}{m^*} \frac{4\pi n e^2}{E_g^2} \left[1 - \frac{E_g}{4E_F} + \frac{1}{3} \left(\frac{E_g}{4E_F} \right)^2 \right]. \quad (40)$$

(Considering the band gap to be much larger than $\hbar\omega_p$, where $\omega_p = 4\pi n e^2 / m^*$ is the plasma frequency, the first term can be neglected. Similarly, $E_g / 4E_F$ is also a small quantity for $E_g \gg E_g$. Then the third term can be neglected. The second term gives

$$\frac{\epsilon_1 - 1}{\epsilon_2 - 1} = \frac{E_g^2}{E_g^1}. \quad (41)$$

The dielectric constants of the materials were measured to be 10–20. Neglecting unity,

$$\frac{\epsilon_1}{\epsilon_2} = \frac{\ln(\sigma_2 / \sigma_0)}{\ln(\sigma_1 / \sigma_0)} = \epsilon_{\infty} \left(\frac{p_L - p}{p_T - p} \right), \quad (42)$$

which proves lever rule. For $R < R_D$ and for one-dimensional system

$$E_d = \frac{1}{R_D N(E)} = \frac{N_d}{N(E)}, \quad (43)$$

where N_d is concentration. This shows that N_{d_1} / N_{d_1} is proportional to $(p_L - p / p_T - p)$.

Now in the case of benzidine-TCNQ, pressure dependence of resistivity is analyzed to give the following relation

$$\ln \rho = A(p - p_0)^{-2/3}. \quad (44)$$

Therefore, $\ln \rho$ vs $\ln(p - p_0)$ is found to be a straight line (Figure 8a). For semiconductor, p_0 is very small so $\ln p$ is plotted.

$$\ln \rho = \ln \rho_0 - \frac{E_a}{k_B T} \tag{45}$$

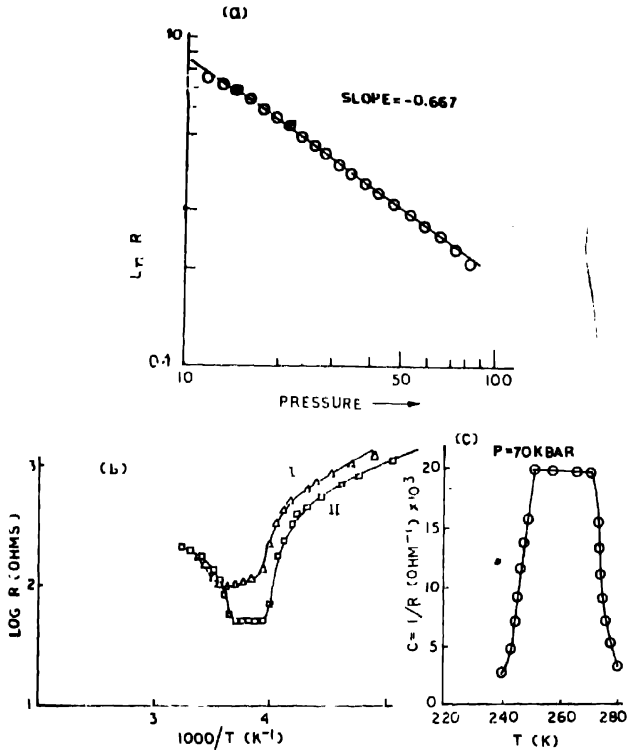


Figure 8. Pressure (a) and temperature (b & c) dependence of resistivity of benzidine-TCNQ (in Figure b curve I for $p = 65$ k bars and curve II for $p = 70$ k bars).

If there is a fluctuation in activation energy arising from density of states, then

$$E_a = E_a^0 + \frac{dE_a}{dn} \Delta n = E_a^0 + \frac{1}{N(E)} \Delta n. \tag{46}$$

$N(\omega) \sim (\omega - \omega_0)^{1/3}$, $n(\omega) = \int N(\omega) d\omega \sim (\omega - \omega_0)^{4/3}$ and $\omega^2 = kP$ for phonons.

4. Temperature dependence of resistivity

The study of temperature dependence of resistivity of various compositions of benzidine-iodine complex led to determination of activation energies of all compositions [28].

Temperature dependence of conductivity of benzidine-TCNQ above 60 kilobar shows a conductivity peak (Figures 8b and c) obeying

$$\sigma = AT^{*1/2} (1 - T^*)^{1/2}, \quad (47)$$

$T^* = T/T_0$ and A is a constant. Actually, it is a beta distribution related with Bernoulli trails for hopping of charge carriers. This relation can be derived from solid state physics as follows.

From the dispersion relation for acoustic phonons like

$$\omega = \omega_m \sin \frac{1}{2} ka, \quad (48)$$

it is easy to see that [30]

$$\frac{dk}{d\omega} = \frac{2}{a} (\omega_m^2 - \omega^2)^{-1/2} \quad (49)$$

and that
$$D(\omega) = \frac{2L}{\pi a} (\omega_m^2 - \omega^2)^{1/2}. \quad (50)$$

The conductivity is proportional to $D(\omega)$,

$$\sigma = B \frac{2L}{\pi a} e\mu (\omega_m^2 - \omega^2)^{1/2}, \quad (51)$$

where μ is mobility and B is a constant. Now $m\omega^2 A^2 = k_B T_2$ where A is the amplitude of vibration. Thus, ω^2 is proportional to temperature T . The mobility $\mu = e\lambda v/m^* v$. λ is mean free path which is independent of temperature in kinetic theory or is limited by wavelength of charge density wave. Only collision frequency is $\nu \sim T^{1/2}$ using kinetic theory. This leads to

$$\sigma = AT^{*1/2} (1 - T^*)^{1/2},$$

where $T^* = T/T_0$. T_0 and ω_m are related directly.

Alternative proof:

Above beta distribution in temperature can also be derived from absorption coefficient. For disordered material, it can be given by [29]

$$\alpha = 0.115 \left(\frac{E_g e^2 m^{*1/2}}{h\nu c_0 \hbar^2} \right) (h\nu - E_g)^{1/2}. \quad (52)$$

For a crystal

$$\alpha = AE_g (h\nu - E_g)^{1/2}. \quad (53)$$

Now $\sigma = \alpha n_1 c / 4\pi$, $n_1 = 1/\sqrt{\epsilon\mu}$, $\epsilon = 1 + \lambda^2/k^2$ and $\lambda^2 = 6\pi n_0 \epsilon^2 / \epsilon_F$. λ is a screening constant [29]. ϵ_F is proportional to temperature T and therefore, $n_1 = B/\sqrt{T}$.

$$\text{Then } \alpha = A \left(E_r^0 - k_B T \right) \left(k_B T - k_B T_0 \right)^{1/2}, \quad (54)$$

replacing $h\nu$ by $k_B T$ and E_r by $k_B T_0$ and $E_r = E_r^0 - k_B T$, we get

$$\begin{aligned} \sigma &= \frac{BA(E_r^0 - k_B T)(k_B T - k_B T_0)^{1/2}}{\sqrt{T}} \frac{c}{4\pi} \\ &= CT^{*1/2} (1 - T^*)^{1/2}, \end{aligned} \quad (55)$$

where $T^* = T/T_0$. T_0 and E_r are related. This is the required beta density.

5. Conclusion

We have studied in detail, the high pressure behaviour of electrical resistivity of organic and organometallic conductors. The beta density behaviour of resistivity vs pressure of these compounds are physically interpreted using some of the basic theoretical models and a general expression for the pressure dependence on resistivity of such compounds are obtained. Other existing alternative models are briefly reviewed and have shown that under some assumptions, most of these models can be deduced to the general theoretical framework discussed in Section 2. The temperature dependence of resistivity of these compounds are also found to have similar beta density behaviour.

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