Mr L. J. Maisey at RAPRA for the g.p.c. determination of the polydispersity of polystyrene PSGY2 with the PSCC columns.

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Electrical resistivity of PVC—Cu composites

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In the past few years research has been conducted to enhance the electrical resistivity of polymers by impregnation of metallic fillers. Conductivity of such polymer composites depends on the concentration of filler[1,2], size ratio of the polymer to metal particles[3–5] and also on the oxide content of the filler particles[4,6]. Matushita *et al.*[7] have made extensive investigations on hot-pressed polystyrene–silver composites and have shown that resistivity of the system could be controlled by compaction pressure through densification of the polymer matrix. The electrical conductivity as well as the strength of the composite shows much lower values when compacted at a lower pressure[8] than that could be obtained by conventional processing[9]. In the present work, a systematic investigation has been made on the dependence of electrical resistivity of poly(vinyl chloride)–copper (PVC–Cu) composites on the compacting pressures at which the composites were prepared.

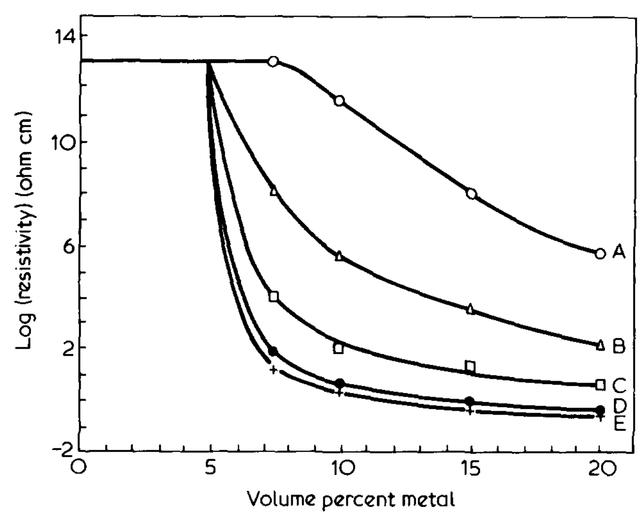

Figure 1 Log (resistivity) vs. vol % metal, A, 10 MNm^{-2}; B, 20 MNm^{-2}; C, 30 MNm^{-2}; D, 45 MNm^{-2}; E, 60 MNm^{-2}

PVC and copper powders of average particle size 128 and 7 µm were thoroughly mixed by tumbling and compacted at a temperature of 130°– 140°C in a steel cylindrical die at a desired pressure. Rectangular specimens (approximately 1.5 x 1.0 x 0.7 cm) were machined out from the briquettes so formed. Prior to the measurement of electrical resistivity these specimens were annealed at 50°C in an oven for 10 days to achieve better reproducibility of the resistivity values[10]. Details of the method of preparation, measurement of electrical resistivity and Vickers hardness of the composites has been reported elsewhere[4,9]. Porosity was calculated from the experimental and the theoretical density values.

Resistivity as a function of metal concentration at different compacting pressures is shown in *Figure 1*. The sharp drop in the resistivity value particularly at higher compacting pressure has been explained on the basis of formation of intermetallic contacts[1,3–5]. Since resistivity of the composites below critical metal loading is controlled by the probability of the metal–ion contact formation[4], we have made experiments only beyond the metal concentration where complete formation of the segregated network is almost achieved. It is observed that at much lower pressure the resistivity vs. metal concentration curve shows a gentle fall because of the changed contact condition due to the improper coalescence of the matrix phase[6,8]. With increasing

Table 1 Porosity and Vickers hardness values of PVC–Cu composites at various compacting pressures

	At 5 volume percent		At 15 volume percent	
Compacting pressure (MNm^{-2})	Porosity (%)	Vickers hardness (kg/mm^2)	Porosity (5)	Vickers hardness (kg/mm^2)
10	25–35	2–5	20–25	4–8
20	15–20	2–6	10–20	4–10
30	8–10	4–8	4–8	14–18
45	3–4	14–16	3–4	18–20
60	3–4	14–16	3–4	18–20

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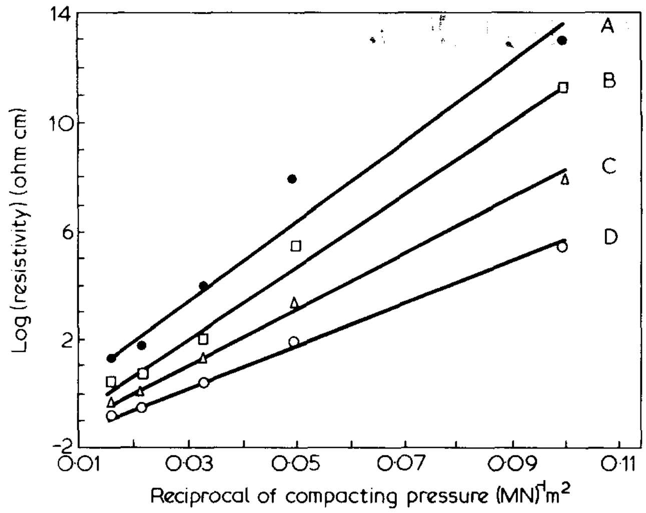

Figure 2 Log (resistivity) vs. 1/(compacting pressure). A, 7.5%; B, 10%; C, 15%; D, 20%

compacting pressure, the coalescence is improved which is reflected in the porosity and Vickers hardness values as shown in *Table 1.* It is to be noted that curves D and E show almost identical resistivity values which probably assures complete coalescence of the polymer phase. *Figure 2* shows the plot of electrical resistivity as a function of reciprocal compacting pressure at various metal concentrations.

In conclusion, electrical resistivity of the PVC–Cu composites could be controlled by the extent of coalescence of the polymer phase with increasing compacting pressure. A relation of the type $\rho = e^{k/P}$ where k is a constant, is established between the compacting pressure (P) and the electrical resistivity (ρ).

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