

Light-coloured conductive fillers for the production of charge dissipative polymers

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Doped-poly(ethylene oxide)-coated minerals (e.g. talc, calcium carbonate) can be used as light-coloured conductive fillers to produce charge dissipative polymer composites.

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Billions of pounds are lost owing to damage caused by static charges¹. The damage can be in the form of failures of electronic equipment as a whole or in parts such as printed circuit boards, transistors, MOS- and FET-based devices. The static charges can also cause ignition and consequently fire. Some modern electronic devices can be damaged² at voltages as low as 25 V. To avoid build-up of charge, charge dissipative materials of surface resistance 10^6 – 10^{10} Ω are used depending on the applications^{3,4}.

Light-coloured polymers are preferred because they can be pigmented for both aesthetic and coding reasons.

Poly(ethylene oxide) (PEO), an ionically conducting commodity polymer, can be used as a filler to produce conducting composites. Furthermore, PEO can be coated onto cheap minerals such as talc and calcium carbonate to produce cheaper light-coloured fillers.

PEO (20 g, M_w 1×10^3 , Union Carbide) was dissolved in 400 ml water and 10 g of *p*-toluenesulfonic acid was added. Talc powder (83 g) was added with vigorous mechanical stirring and the mixture was heated to 100°C, cooled to room temperature, filtered at suction, washed with deionized water and dried at 100°C *in vacuo* for 12 h. The white powder (78 g) had a d.c.-volume conductivity of 7.6×10^{-7} S cm⁻¹.

PEO (200 g, M_w 4×10^6 , Union Carbide) was dissolved in 20 l water maintained at 95°C. CaCO₃ powder (80 g) was added followed by 10 g Fe(III) acetate and the solution was stirred for 2 h. The solution was then spray-dried. The resultant powder had a d.c.-conductivity of 10^{-5} S cm⁻¹.

The physical properties of the PEO-coated calcium carbonate (PEOCC) are summarized in Table 1. PEOCC was compounded into poly(vinyl chloride) (PVC) at 140–160°C in the presence of dioctylphthalate (DOP, 50 phr) as a plasticizer and tin thioester (Sn/C from Chemson, Germany) as a stabilizer on a two-roll mill to produce 1 mm thick plaques. The surface resistivity was measured using a ring electrode and the charge decay

Table 1 Physical properties of PEO-coated calcium carbonate

Property	Value
Density	2.61 g cm ⁻³
Mean particle size	6.6 μ m
Surface area	1.87 m ² g ⁻¹
Moisture content ^a	0.93%
pH ^b	7.2

^a Determined after 24 h at 80°C in vacuum oven; normally the upper limit owing to loss of some powder in dynamic vacuum condition

^b Determined at 25°C after heating the powder in water for 30 min at 100°C

Table 2 Electrical characteristics of PEOCC/PVC composites

Loading level (% w/w)	Stabilizer	Plasticizer ^b	Surface resistivity (Ω)	Charge decay time constant (ms)
40	Tin compound ^a (3 phr)	DOP (50 phr)	9.6×10^8	50
50	Tin compound ^a (3 phr)	DOP (50 phr)	8.0×10^8	50
40	Tribasic lead sulfate (3 phr)	DOP (50 phr)	9.5×10^{11}	1240
40	Tribasic lead sulfate (3 phr)	DOS (50 phr)	3.0×10^{11}	810
40	Tribasic lead sulfate (3 phr)	DIOZ (50 phr)	2.8×10^{11}	830

^a Tin thioester from Chemson

^b DOP, dioctylphthalate; DOS, di-2-ethylhexyl-sebacate; DIOZ, di-iso-octylacetate

time using a charge decay meter produced by John Chubb Instrumentation (Cheltenham).

Table 2 summarizes the electrical characteristics of the PEOCC/PVC composites. It is clear from Table 2 that the tin stabilizer produces the most conductive composite. Tribasic lead sulfate stabilizer must have a specific interaction with the PEOCC system so that the conduction is inhibited. The charge decay time constant of 50 ms is within the range required by most specifications (where the limit is between 10 ms and 500 ms) for charge dissipation applications.

In conclusion, it is possible to produce a light-coloured charge dissipative polymer composite based on doped poly(ethylene oxide) which is commercially viable. Minerals coated with inherently conducting polymers, such as poly(aniline)s, poly(pyrrole)s and poly(thiophen)s, should also have commercial potential⁵. A study of this

will be published elsewhere. The PEOCC/PVC composites might also be used in ion sensor applications.

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