The effect of DOP plasticizer on smoke formation in poly(vinyl chloride)

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A strong positive correlation exists between the amount of the organic plasticizer di-(2-ethyl hexyl)phthalate and the amount of smoke production in burning poly(vinyl chloride).

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In spite of the current trend towards the use of non-halogenated polymers and halogen-free flame retardants, poly(vinyl chloride) (PVC) continues to be used in large quantities throughout the world. In the UK alone the growth in use of PVC in recent years has been quite substantial. In 1985, 450 × 10^3 tonnes of PVC were consumed and this rose to 620 × 10^3 tonnes in 1989[1], PVC representing about 20% of all plastics used worldwide. There are essentially two major types of PVC in use today. Rigid PVC formulations containing a few parts per hundred (phr) of stabilizer and processing aid and semi-rigid/fully flexible formulations containing up to 80 phr organic plasticizer, such as dioctyl phthalate (di-(2-ethyl hexyl)phthalate, DOP), together with stabilizer and lubricant. These rigid and semi-rigid/fully flexible formulations have very different properties and these different properties are reflected in their commercial use.

We have recently examined the effect of adding DOP to a rigid PVC formulation and determined limiting oxygen index (LOI)[2] and smoke data[3] for the resulting formulations containing 0, 10, 20, 30, 40 and 50 phr of DOP in PVC (*Table 1*).

Although there continues to be great debate about the implications of smoke data with respect to real fire situations[4], the NBS smoke density chamber continues to be very widely used as a laboratory tool and quality control technique for assessing smoke production from burning polymers[2]. We used a Stanton Redcroft model smoke density chamber in the flaming mode for this study.

The attenuation of a light beam caused by smoke collecting in the test chamber is measured. The smoke is generated by pyrolysis (smouldering conditions) or combustion (flaming conditions). The results are expressed as specific optical density, a measurement characteristic of the concentration of smoke. The maximum specific optical density, D_{max}, is calculated using the minimum light transmittance.

At least three samples of polymer are exposed to a heat flux of 2.5 W cm^{-2} and in addition during the

Table 1 LOI and smoke data

DOP in PVC (phr)[a]	LOI	Smoke density D_{max} (corr. 7 g)	Smoke density D_{max} (g^{-1})
0	49.8	250	25.7
10	38.7	310	44.3
20	31.5	390	55.7
30	28.0	450	64.3
40	25.0	520	74.3
50	23.9	600	85.7

[a] 100 phr Corvic S67/111, PVC polymer; 5 phr tribasic lead sulphate stabilizer; 1 phr calcium stearate, lubricant

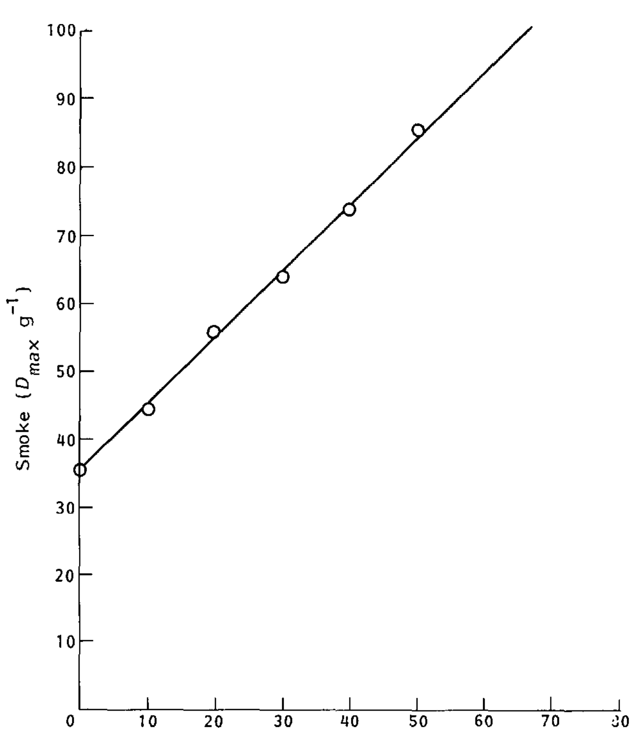

Figure 1 Relationship between smoke production and DOP

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flaming mode of the test, six micro burners are placed 6.4 mm away from and 6.4 mm above the lower edge of the specimen.

We plotted the smoke value (D_{max} g^{-1}) against phr of DOP in PVC and found a rather unexpected relationship (*Figure 1*). *Figure 1* shows that there is a very strong positive correlation ($r = 0.999$) between the amount of DOP present and the smoke produced. It would appear that the amount of smoke produced is directly related to the DOP present in these formulations and smoke production is therefore determined by the plasticizer and not to any great extent by the PVC. Unfortunately the same relationship does not apply to the LOI data.

References

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