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Effect of sands on poly(vinyl chloride) resistance to ultraviolet light

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SUMMARY

Laminates made of poly(vinyl chloride) (PVC) and sands were irradiated by ultraviolet light (UV) under normal atmospheric conditions. Three different types of sand (mine, beach and river) were utilized at various concentrations levels. The effect of the sands upon flexural mechanical properties of the laminates with varying irradiation times was analyzed. It is shown that degradation induces a decrese in mechanical properties of PVC laminates but this may be prevented by adding mine sand at specific volume concentration.

INTRODUCTION

The use of plastics materials in construction and building requires that the outdoor durability of polymeric materials should be optimized by improving weathering resistance . Many factors, such as temperature, humidity and solar radiation cause degradation in polymers. Ultraviolet radiation from sunlight (280-380nm) or from artificial light induces a decrease in physical and chemical properties of polymers (1,2,3).

In previous studies (4,5) the use of mineral fillers, such as sands mixed with polyolefins, was shown to prevent degradability and enhance protection againts weather.

The methods that have been applied to predict the perfomance of polymeric materials under accelerated weathering are based on measured changes in the chemical and physical properties of polymers(6,7,8,9).

In this study the effect of UV radiation on a composite material based on PVC and three different types of sands was investigated. Because this composite may be used to produce laminates for construction purposes, the protective

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effect of these sands on the degradation process is evaluated by measuring the changes in the flexural resistance of the laminates.

EXPERIMENTAL

The composite used for sample preparation was made of PVC, dioctyl phatalate (DOP) as plasticiser and lead stearate as antioxidant, with proportions of 100, 15 and 3 %wt respectivelly.

PVC used was of commercial grade with average molecular weigth (Mw) of 179,000 and a polydispersity of 1.9, determined by gel permeation chromatography .

The fillers were three types of sand: mine, river and beach. The main components of the first are quartz, feldspats and crystobalytes; the second sand contains quartz and fedspats and the last one quartz, carbonates and aragonite (3). The three sands have about the same particle diameter (~500 μm) with densities of 2.51, 2,61 and 2.6 g/cm^3, respectively. Before mixing the sands were dried at 110°C during 6 hours. The UV radiation was of 300nm wavelength and 0.4 W/m^2 intensity, in a normal atmosphere at 50°C. The distance between lamps and sample surfaces was 4 cm. Mechanical properties were studied by an Instron testing machine, model 1125. Molecular weigths were determined by gel permeation chomatography (GPC) using a Waters 150C instrument and polyestyrene caligration standards. The solvent was tetrahydrofuran from Baker.

Sample preparation

Laminates made of pure PVC and fillers were produced in a molding press at 200°C and 2.9 MPa. The thermoforming time for each composite was determined experimentally because it increases with filler concentration.

Both faces of the composites were exposed to UV radiation from 0 to 400 hours. At least 5 specimens were exposed at the same conditions. Samples were characterized by flexural tests, performed at 1.27 mm/min deformation velocity following ASTM D-790 .

Figure 1 shows the variation of thermoforming time with filler content for the three PVC-filler laminates. Filler content in this case was as high as 62.5% (vol). The resulting thickness of the laminates was set at 2.5 mm and they were cut in 80 x 25 mm specimens.

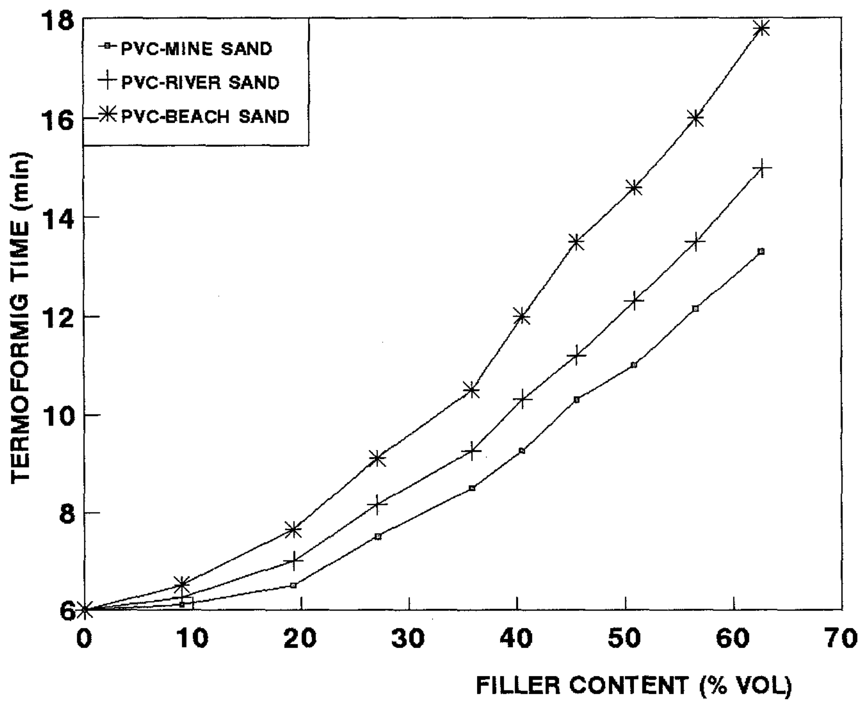

Fig.1 Termoforming time vs. filler content for the three PVC-sand composites at T=200°C

RESULTS AND DISCUSSION

Mechanical properties

Figure 2 shows flexural strength of PVC-filler laminates as a function of filler concentration. The behavior of the laminates is similar and the curves may be analyzed by dividing them into three different sections. In the low concentration section (up to 30 volume percentage) the flexural strength decreases with the filler content. This effect may be attributed to poor interfacial adhesion between filler and matrix. In the second section (30-56% vol) the curves show an upward trend with the increase in volume fraction. At this point, optimum particle packing of the polymer matrix is reached. This effect has also been observed in systems such as poly(phenylene oxide) filled with silane-treated glass (10) and a polyester composite filled with treated glass (11). Nielsen reported some theoretical justifications for such behavior (12). It should be noted that the flexural strength of the PVC-~56% mine sand system is larger than pure PVC.

For higher volume contents (more than ~56% vol), the strength decreases again, reflecting a system with discontinuous granular consistency. In this region, the maximum packing fraction is exceeded and this gives a sharp change in the external appearance and mechanical properties.

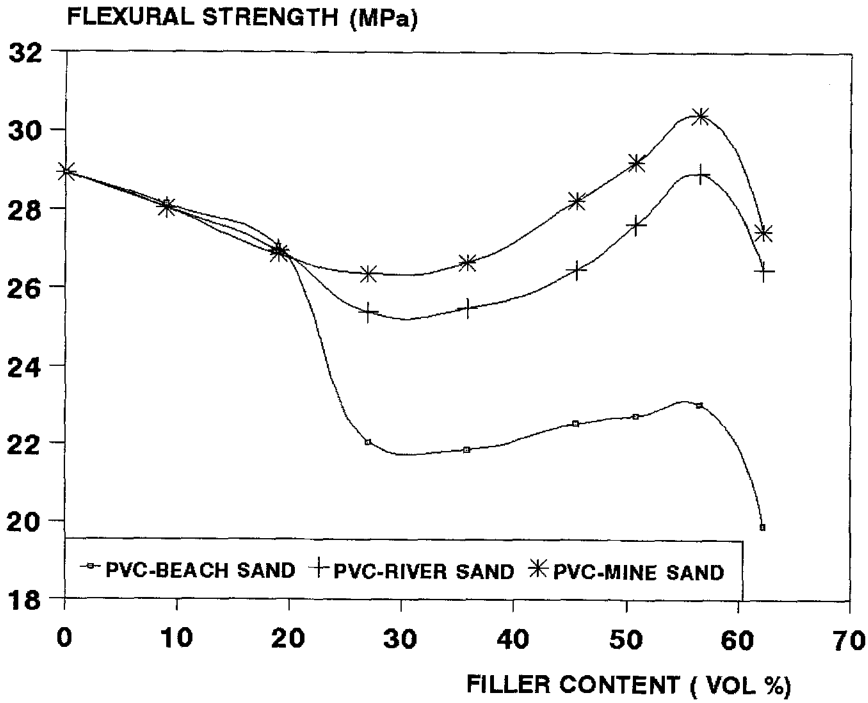

Fig.2 Flexural strength as a function of filler content.

Degradation effects.

Studies made on the mechanism of degradation on PVC have shown that the primary products formed during UV radiation are HCl and conjugated polyenes, which influence all related processes, i.e., chain scission, crosslinking, oxidation, discolóration, etc. In UV radiated PVC samples the main process observed is chain scission (13), while crosslinking may occur to a limited extent (14,15).

Figure 3 shows that the average molecular weights decrease during irradiation. This indicates chain scission.

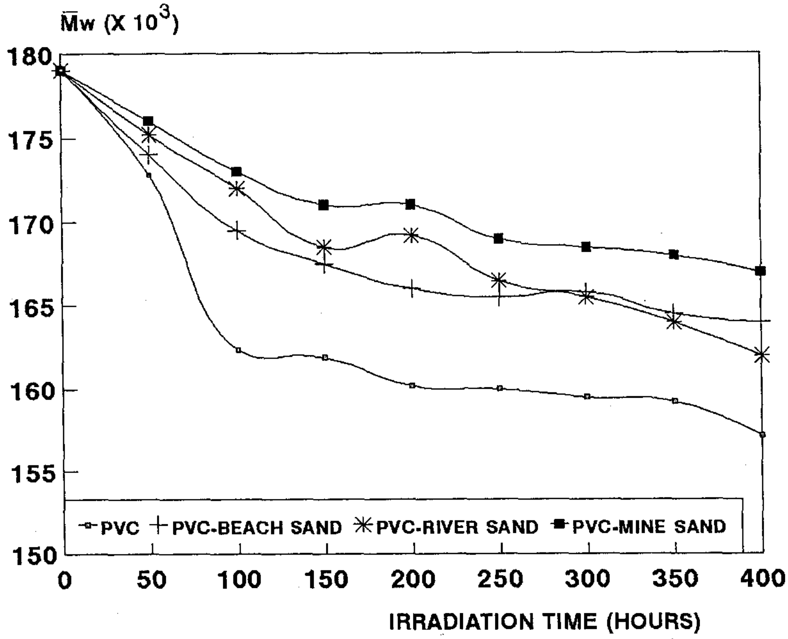

Fig.3 Weight average molecular weight as a function of irradiation time

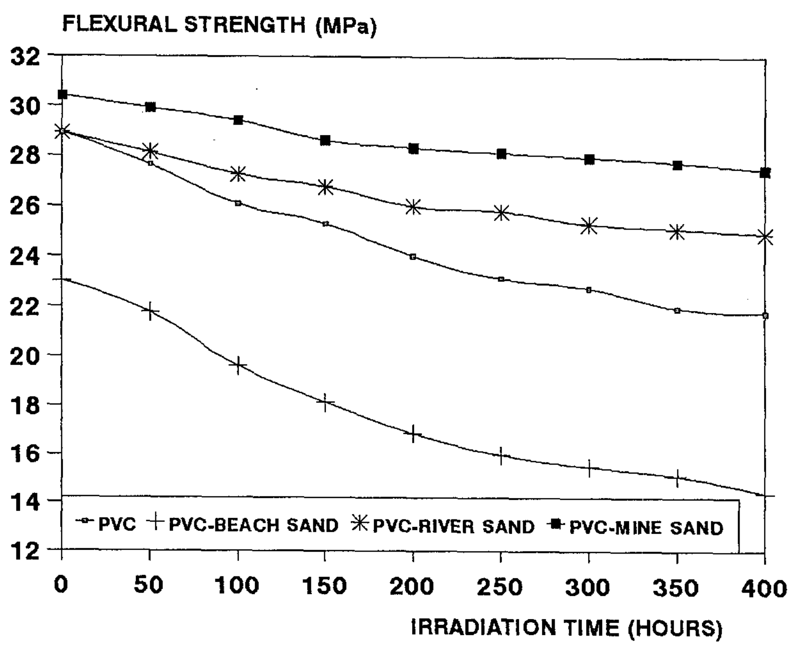

Fig. 4 Flexural strength as a function of irradiation time for PVC and PVC-sand (~56 vol% sand) composites.

Figure 4 shows the variation of flexural strength with irradation time for PVC and PVC-sand samples containing concentration of 56.0 % sand. The curves show a decrease in the flexural strength, being largest for the PVC-beach sand composite. The resistance to degradation is more apparent in the presence of mine sand.

CONCLUSIONS

Mine or river sands protect against PVC degradation. The best results were obtained with a PVC-mine sand composite and the worst with beach sand. The optimum sand concentration in the composite was 56 vol%.

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